Common Commodities and Industries

WHEAT

A. Millar

WHEAT

AND ITS PRODUCTS

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PITMAN'S COMMON COMMODITIES
AND INDUSTRIES

WHEAT

AND ITS PRODUCTS

A BRIEF ACCOUNT OF THE PRINCIPAL CEREAL: WHERE IT IS GROWN, AND THE MODERN METHOD OF PRODUCING WHEATEN FLOUR

BY

ANDREW MILLAR

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PREFACE

When I undertook to write a short book on wheat, its habitat, its transportation, and the production from it of wheaten flour, I set two objects before me. The first was to tell in simple language, with as few technicalities as possible, whence and how the raw material is obtained and to describe the modern method of producing flour, so that my work might be of interest to all classes of readers. The manufacture of flour is now such a science, that technicalities cannot altogether be avoided in dealing with the subject; but I have tried to simplify the terms so that those who know little, or nothing, of the industry may be easily able to understand the various processes through which the grain passes before pure flour is ready for the use of the housewife or baker.

We read so much of the wheat fields of the United States and Canada, as also of those of India, Australia, and Argentina, that most people will be surprised to learn that more than half of the world's wheat crop is still grown in Europe.

My second object has been to write a book so technically correct that it shall be both interesting and useful to millers and all others connected with the breadstuffs industry. How far I have succeeded, I must leave to the judgment of my readers.

Flour milling is, even yet, in such a state of transition, and new methods and machines are so continually being introduced by milling engineers and their experts, that only by the constant study of the trade journals can millers keep themselves well informed of the latest innovations in the process of manufacture.

I am deeply indebted to the following firms for information and for the loan of illustrations used in this book, viz.: Messrs. Bryan Corcoran, Ltd., Engineers, 31 Mark Lane, London; Messrs. Samuelson & Co., Ltd., Engineers, Banbury; Messrs. Spencer & Co., Engineers, Melksham; Messrs. Henry Simon, Ltd., Engineers, Manchester; Messrs. E. R. & F. Turner, Ltd., Engineers, Ipswich; *The Miller* journal, 24 Mark Lane, London; and to Messrs. W. Vernon & Sons, Millers, London and Liverpool.

ANDREW MILLAR.

LONDON,
March, 1916.

NOTE.—Import, crop, etc., tables corrected to January, 1921.

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CHAPTER I

THE GEOGRAPHY OF WHEAT

WHEAT (*Triticum vulgare*) is one of the group of farinaceous annual grasses of which rye, oats, and barley are the next three of most importance. Wheat is divided into two principal classes—winter and spring, winter wheat being that which is sown in autumn and stands the winter. In colder climates it is important that the young plant shall be protected from the most severe frosts by a covering of snow.

Spring Wheat, as the name indicates, is sown in spring and so escapes the rigour of winter. Many varieties of the cereal do almost as well in Great Britain whether planted in winter or spring.

Of the origin of wheat, or of the country which first produced it, little is known. It has been contended that it was evolved, perhaps in prehistoric times, from some species of grass; but of this there is not the slightest evidence, and, though it may have been developed by cultivation, there is hardly a doubt that it was always a distinct plant. Humbolt in his *Aspects of Nature* says, "The original habitat of the farinaceous grasses is wrapped in the same obscurity as that of the domestic animals which have accompanied man since his earliest migrations," and no one has been able to throw any light on the subject.

Probably it was a native of Asia Minor, and, as it is mentioned in the oldest records, it was obviously known and valued as a food by primitive man.

Wheats are commercially of two colours, red and white, but actually there are several shades of each; yet even a novice would have little difficulty in classifying any sample under one of the two colours, though he might suggest that some of them were yellow.

The varieties of wheat at the present day are unlimited, or practically so, due in a great measure to changes caused by environment, the nature of the soil on which it is grown, climatic conditions, and hybridisation. In some parts of England white wheats will, in a few seasons, become red when grown and seeded on the same farm year after year, and red wheats soon become white if grown continuously on the Pacific slopes of America.

Though temperate zones best suit the cereal, yet it can be grown in a very wide range of climates and, more or less, in any kind of soil, though naturally it does much better in some soils than others. But it does not necessarily follow that the land that grows the heaviest crop yields the best wheat from the miller's, baker's and bread-eater's point of view, and, generally speaking, a small-berried wheat produces better flour, and so better bread, than a large berried sort. Although this cereal grows best under temperate zones, yet it is grown under such a wide range of climate that it seems not impossible that it may in time be grown in most of the tropical latitudes.

Mr. A. E. Humphries, of Weybridge, in a paper on "The Production of Wheats in the Tropics," points out that temperate zones exist in the tropics, altitude being as important as latitude.

Thus Mexico grows 2,000,000 quarters of wheat on her central tableland at altitudes of from six to ten thousand feet. Honduras, Venezuela, Colombia, Peru, and Bolivia all produce some of the cereal on their high tablelands, while Equador, situated on the Equator, grows enough some years to be able to export a small quantity. Brazil has given the matter of wheat-growing considerable attention, and has managed, not very successfully, to grow small quantities on an experimental farm at Victoria Espiritu Santos. India, of course, has vast wheat-fields, but not much of their area is in the tropics. The Sudan produces considerable quantities, though cotton has to a great extent supplanted wheat as a chief crop in Egypt. The great bugbear to every grower in warm countries is rust (*Puccinia Graminis*), but scientists appear likely to be able to overcome this trouble by breeding rust-proof varieties.

Going to the other extreme of latitude, within recent times the northern limit to the wheat belt has been extended so far towards the arctic circle in Canada, that regions in which, a generation ago, it would have been deemed impossible to grow wheat, are now, in favourable seasons, producing some of the best wheat that is grown. The chief risk that the farmers run in the Canadian North-West is from early frosts. These frosts catch the wheat in what is known as the "milk" stage of growth and prevent the development of the grain. After the wheat has passed the "milk" stage it is safe from frost.

In the extreme north of Russia, and in Norway and Sweden, the crop is always a precarious one, and in the north of Scotland little is grown; but this may be partly due to the importance of the oat crop grown there, and the greater certainty of profit from it than from wheat-growing.

In the southern hemisphere Australia and Argentina are the two chief wheat-growing countries, with Chile ranking third.

Most countries grow distinctive sorts of wheat, and each has established types that are seldom departed from now, though it is interesting to note that in some cases it took new countries quite a long time to settle down to a particular class of grain.

For instance, when Canada first became an important exporter she grew nearly all white wheat; but within the last thirty years red wheat has quite taken the lead, and very little white wheat is grown there now except on the Pacific slope. The great demand of millers, bakers, and bread-eaters is for strong wheat, though probably the latter do not know it. Strength in wheat is that quality which will produce a large, light, well piled loaf of good texture; and strong wheats are as a rule more expensive than the weak ones, and have a higher nutritive value.

Two chief sources of strong wheat are Russia and North America, including Canada, the Spring Wheats of the latter being generally stronger than the Winter.

Australia, as is well known, is subject to severe droughts from time to time, and though wheat will endure more dry weather than most crops, owing to its very deep rooted habit of growth, yet it must of necessity be supplied with some moisture. The Commonwealth, which generally has a large surplus of grain to export, had in 1915 to import a considerable quantity for her own use owing to the drought of the latter months of 1914.

The huge irrigation schemes being carried out in Australia will render large areas of the country more or less independent of the rainfall.

Australian wheat is white, of good quality, and generally commands the highest price of any on the English market. It is not of the strongest class, but it yields a large percentage of flour of good colour. The grains are brittle and need the application of water to toughen them before they can be scoured and cleaned.

New Zealand, which used to export wheat, has of late gone in so extensively for stock and other farming that she does not produce more breadstuffs than her own population requires.

Russian wheats all have the same general characteristic, but it is doubtful if any of them are of pure type. Nearly all are red wheats, strong and hard of structure, and generally small in the berry. They are known in a general way under the names of Azima and Ghirka, the former being Winter wheat and the latter Spring. The chief cause of complaint in regard to these is the large percentage of impurities that they contain. There is no system of grading them into standard qualities. Screenings and dirt are often wilfully added for shipment, and it is only safe to buy them from samples with a guarantee that the shipment shall be equal to the sample, and contain no higher percentage of impurities. The South Russian wheats, grown largely on what is termed the black earth zone, would, if properly harvested, be of the choicest quality.

The climate is much like that of the North Western States of America, the winters being cold and the summers brilliantly hot. Most of the rivers are frost-bound for some part of the winter, as are the Black Sea ports from which the bulk of Russian wheats are exported. The grain, like that from many other parts of the world, is largely named after the ports from which it is shipped, such as Odessa, Taganrog, Nicolaieff, etc., in the Black Sea and Sea of Azof. At times a considerable quantity of wheat is shipped from Baltic ports, the two best sorts coming from there being known as Saxonska and Kubanka. There is always danger of North Russian wheats being frosted, and especially so those grown in the extreme north and shipped via Archangel.

Russian wheats have a strength quality that makes them especially valuable for mixing with weak English sorts. The Russian State Bank is providing the means for building grain "silos," or, as the Americans call them, "elevators," on the American plan at local centres, for the storage of farmers' wheat, and it makes advances on the wheat stored. A great number of these *silos* have already been built and more are under construction.

Austro-Hungarian wheat, and that grown in the Danubian provinces, is much of the same type as the Russian, with some slight variations in the size and the structure of the berry, due partly to environment, and partly to better methods of cultivation.

As we proceed westward we come on softer types till, when Great Britain is reached, we find the cereal larger in the berry, with a softness of structure and a marked lack of strength, but with a flavour which gives it its chief value to the British miller as a commercial factor. The variations in the quality of English wheats are perhaps greater than in those of any other country. Strong wheats can be grown, and are, but usually the yield per acre is so low that farmers prefer to grow a poorer quality that will give a better yield per acre.

Millers and farmers value wheat from somewhat different standpoints. The former chiefly considers the quality and condition (dryness) of the grain, while the latter is more concerned with the number of quarters he can produce per acre. The possibility of producing a strong wheat, giving a good yield per acre, is a subject in connection with which the Home-Grown Wheat Committee of the National Association of British and Irish Millers has been working for a number of years. It has produced Burgoynes Fife, a cross between Essex

White and Canadian Fife, which is the best milling wheat grown, so far, in England; and Mr. A. E. Humphries, of Weybridge, the chairman of the committee, has expressed the opinion that they can produce a miller's wheat that shall be such a heavy cropper that it will pay farmers to grow it in preference to any other.

Canada, with her long winters and short summers, produces comparatively little winter-sown wheat, the bulk of her crop being sown late in the spring and harvested in the late summer; and the wheat line is ever being pushed further into the North West as railways are constructed to take the farm produce to market. About half the Canadian wheat exported is shipped from United States ports, but now the Panama Canal is opened the Far West Canadians hope to ship via the canal from their own Pacific ports.

Owing to the short summers, early ripening wheats are necessary; and many sorts have been introduced which claim to have this characteristic. The Spring Wheats of Canada are generally the highest priced that reach the European markets. They are strong, and much freer from impurities than the Russians. They are sold under the name of Northern Manitoba, though some of the more western provinces are jealous of the name, and have tried to have their crop known as Northern Canadian, without, so far, any success. Winnipeg is the great wheat centre and market. The grain is shipped chiefly via the Great Lakes, and, after the completion of harvest, it is not unusual for 1,000 carloads of wheat to pass through Winnipeg in a day *en route* for the lake ports. The Dominion now ranks fourth among the countries of the world as a wheat producer.

The United States dominated the wheat markets of the world for nearly two generations. It was the opening up of the western prairies that brought the price of breadstuffs down to the level that has prevailed with little variation since 1884. These new lands required, or at least seemed to require, no cultivation, as it is understood by British farmers. The land was ploughed and seeded, and nothing more was done till harvest, when the grain was cut and threshed and the straw was burnt. Then the stubble was ploughed and the ground planted again with wheat.

That the land only produced some 13 bushels per acre as against 32 bushels grown in England did not much matter. The land was cheap and plentiful, and, when worn out, more was available further west. Practically all the wheat grown in the middle and eastern States is red, about two-thirds being winter sown and one-third spring sown. On the Pacific slopes the wheat grown is nearly all white, and originally it was shipped under the general name of Californian. It is a dry, brittle, weak grain, but produces a white flour with a creamy tint. Little of it comes to Europe now, though white wheats are still shipped from that coast, but are chiefly grown in Oregon and Washington. The best known are Walla Walla and Blue Stem, grown on the higher lands near the mountain ranges, and shipped chiefly from Portland, Oregon, though some is also exported via Seattle and Tacoma.

Kansas is perhaps the most important wheat-growing state in the Republic, and gives its name to the wheat produced in the district, which is highly appreciated by millers and known as Kansas Hard Winter. The wheats grown further south are of a milder, mellower nature, and lack something of the strength of the Kansas. Hard spring wheats come from the more northern states, the chief growers being Minnesota and the Dakotas. These wheats, though smaller in the berry than winters, are much stronger in the milling sense of the word.

Chicago is the principal wheat market in the United States, and the fame of the Chicago Wheat Pit is known all over the world. On various occasions, when there has been a short crop, speculators have formed a "corner," *i.e.*, a group of them have tried to buy up all the wheat, and, in fact, more than there was, so that they could fix their own price to those who had sold more wheat than they could deliver. Unfortunately for those who have tried to "corner" the market, events proved that there was more wheat than money on each occasion, and the "wheat ring" failed. One of the jokes in this connection is the saying that only one man ever successfully cornered wheat, viz., Joseph in Egypt.

Minneapolis is the greatest milling centre in the world, the output of her flour mills far exceeding those of any other city on the globe. Her predominance is due to the enormous water-power of the famous Falls of St. Anthony. London of late years has claimed second place, but a very poor second, to the American city. Improved farming methods are increasing the yield per acre in America, the average for **1915** being about **16½** bushels per acre.

India is another of the four principal wheat-growing and exporting countries; Russia, North America and the Argentine being the other three, though Australia is often a good fifth.

Indian wheats are generally of a dry, harsh, ricey character and are chiefly white, grown in the alluvial soils of the great river valleys and plains. Red wheats are grown on the higher sandy soils, and are considerably harsher and poorer than the white sorts. The primitive manner of harvesting and threshing is responsible for the dirty condition of these wheats, which contain a generous mixture of dirt and small stones, besides foreign seeds of many sorts. The extent of the crop depends largely on a satisfactory monsoon for seeding. The bulk of the surplus is shipped before the monsoon, as there are no modern storage arrangements, and that which is held till later in the year is likely to be seriously damaged by the wet and by weevils. Huge irrigation works in India have already been carried out, and so many other schemes are in hand that the wheat yield is slowly becoming, more or less, independent of the rainfall, as the fields can be watered artificially. The wheats are named generally after the three chief ports of shipment, viz., Calcutta, Bombay and Karachi. Another sort is known as Soft White Delhi. There is also Soft Red Delhi from the same district; in fact, there are reds and whites from the three ports named. The wilful adulteration of these wheats by the addition of loose dirt has been stopped to some extent in late years, but the practice seems to be too deep-rooted amongst the natives to ever be entirely eradicated, except by the erection of Government elevators, as in Canada, where wheat is screened as received and the impurities rejected.

Though the Indian wheat crop has often been one of the determining factors in regulating the world's price of breadstuffs, but little is known to the ordinary Englishman of the position of the principal wheat-fields of the great Dependency. The wheat-growing area of the Indian Empire, includes the whole of Northern India, and, though it is grown almost everywhere to some extent, it flourishes chiefly in the Punjab and the United Provinces, which produce about 75 per cent. of the total wheat crop, which ranks third in the Empire, it being headed by rice and millet. Though many varieties are known to British millers, they can generally be classed as soft and hard reds and whites, Northern India producing most of the softer sorts, while the hard ones come from Southern India and Bengal. The white wheats are more freely exported than the reds, which are more popular for home consumption in the land of their growth.

Till the advent of Europeans the art of making fermented bread seems to have been unknown, and wheat products, coarsely ground, were baked in the form of cakes, or made into a kind of porridge. The substitution of modern European mills is gradually altering this, as well-milled flour is now a much appreciated article. A large and growing export trade has been established throughout the East, Bombay being the largest shipping port for flour, and Karachi and Calcutta the second and third respectively.

Chile is the oldest wheat-exporting country in South America, and, in years gone by, used to send considerable quantities to Europe. The grain, like that of the North Pacific coast, is of the white variety; but of late years little or none has reached British mills.

The Argentine Republic has now become one of the most important wheat-growing countries of the world. Though in 1882 she only exported 8,000 quarters, yet, thanks to her great rivers and her immense alluvial plains, in conjunction with almost unlimited British capital to build and develop her railways, her exports of wheat have more than once prevented breadstuffs reaching famine prices in Europe. Her wheats are all red and of a medium strength, though, owing to the vast extent of the country in which they are grown, and the different climatic conditions prevailing, they vary in quality to a considerable degree. As in other countries, the production of cereals here depends very much on the weather, and the exportable quantity as well as the quality varies considerably from year to year.

Argentina exports large quantities of breadstuffs to other South American states, both in the shape of wheat and flour, the latter being the output of her large port mills. Her wheats are always welcomed by European millers, coming as they do at a time when the supplies in the Northern Hemisphere are often running low. They yield quite a white flour, considering the colour of the grain—a flour that will make a nice flavoured loaf when used alone, but too weak to carry much English wheat flour.

Africa.—Wheat is grown along the Northern shores of the Dark Continent, but the crop is not an export one in South Africa. The growth of the cereal is, however, increasing in the latter half of the Continent, in spite of the fact that it is liable to many diseases north of Cape Colony. In Cape Colony there are a number of large modern flour mills.

Seed-Time and Harvest.—The following table gives the usual seed-time, and the beginning of the harvest, in most of the world's wheat-fields. The last column gives dates when new crops from the various countries may be expected in the United Kingdom. How long they continue to come depends on the exportable surplus grown from year to year.

Seed-time.	Country.	Harvest.	Arrive in U.K.
July-Aug. .	India and Upper Egypt	Feb.–Mar. .	June–July
Aug.–Sept.	Syria, Persia, India, Mexico . . .	April . .	July-Aug.
Aug.–Oct.	Algeria, Central Asia	May . .	,,
,,	Japan, Morocco, Texas	,, . .	,,
Sept.–Oct.	Southern Europe	June . .	,,
,,	California	,, . .	Jan.–Feb.
,,	Kansas and Southern Winter States .	,, . .	Aug.–Sept.
Mar.–April	Early American Spring States . . .	July .	Oct.–Nov.
Sept.–Oct.	Central Europe and Southern Russia	,, .	,,
Mar.–April	Northern American Spring. . .	August .	,,
Sept.–Oct.	Oregon and Washington	,, .	Mar.–Apr.
Mar.–April	South Canada	,, .	Oct.–Nov.
April–May	North Canada and N.-W. States .	Sept. . .	Nov.
April . .	North Russia.	,, . .	Dec.
May-June	Argentina	Dec.-Jan. .	Feb.–Mar.
,,	Australia, New Zealand, Chile . .	,, .	Apr.–May

When Great Britain had to depend on her own wheat crops, periods of partial famine were not unknown ; but to the steam-engine may justly be given the credit of having made the danger of famine a thing of the past by opening up the fertile areas of the New World, and by facilitating the transportation of grain from the wheat-fields of the world to her own shores. The crop of one or another of the exporting countries may fail, and the exportable surplus be small or nil ; but this has always been balanced as far as Europe is concerned by abundant yields in some of the other grain-growing and exporting countries.

The following table, published by the Board of Agriculture, gives a good idea of how the sources of supply vary. The Russian and Australian figures show perhaps the greatest irregularity, but all show evidence of lean and fat years in the lands to which they refer.

The small Russian export for 1914-1915 was, of course, due to the closing of the Dardanelles, while that of Australia was due to drought.

The years in the following table are cereal years, *i.e.*, from 1st September of one year to 31st August of the next.

Country of Export.	Thousands of Cwts.							
	1919–20	*1919	*1918	*1917	*1916	1915–16	1914–15	1913–14
India	—	—	692	2,746	5,615	2,911	16,018	11,477
Russia	—	—	—	111	12	523	635	9,566
Argentioa	34,018	6,887	14,390	6,716	4,513	3,337	12,175	6,991
U.S.A.	36,106	42,043	42,720	62,249	69,726	71,041	40,806	30,496
Canada	14,753	23,430	21,533	22,363	25,778	29,435	25,159	24,977
Australia	26,846	16,530	3,693	11,095	4,200	2,740	1,297	14,300

Country of Export.	Thousands of Cwts.					
	1912–13	1911–12	1910–11	1909–10	1908–9	1907–8
India . .	23,152	21,468	21,460	16,077	10,904	10,480
Russia .	7,379	8,520	25,728	27,911	9,470	4,455
Argentina	18,617	16,823	16,983	11,405	24,542	28,128
U.S.A.	31,569	16,619	9,479	14,911	19,299	25,273
Canada .	21,249	19,819	13,826	18,539	15,118	13,578
Australia. .	9,738	15,170	10,417	11,915	9,587	6,264

*For Calendar year. Cereal year not available.

The following table, published by the Board of Agriculture, gives the quantity of wheat grown in the United Kingdom and the quantity of breadstuffs imported each cereal year, for the last seventeen years.

Harvest Year.	Wheat Crop of the United Kingdom.	Imports of Wheat during the Cereal Year, Sept. 1–Aug. 31.	Imports of Wheat Flour in equivalent Weight of Grain.	Total Imported Wheat and Flour in equivalent Weight of Grain.	Total estimated Wheat Grain available for home consumption (including seed).
	Qrs.	Qrs.	Qrs.	Qrs.	Qrs.
1903–4	6,102,300	21,723,820	6,203,350	27,927,170	34,029,470
1904–5	4,740,000	24,529,170	3,526,620	28,055,790	32,795,790
1905–6	7,541,600	22,063,580	4,677,330	26,740,910	34,282,510
1906–7	7,577,300	22,105,180	4,284,290	26,389,670	33,966,970
1907–8	7,066,400	21,362,720	4,339,090	25,701,810	32,768,210
1908–9	6,741,200	21,727,220	3,554,650	25,281,870	32,023,070
1909–10	7,899,600	24,099,060	3,501,520	27,600,580	35,500,180
1910–11	7,074,200	23,516,140	3,263,380	26,779,520	33,853,720
1911–12	8,039,200	24,109,260	3,324,140	27,433,400	35,472,600
1912–13	7,175,300	26,500,565	3,648,883	30,149,450	37,324,750
1913–14	7,087,100	23,267,175	3,654,048	26,921,220	34,008,320
1914–15	7,804,000	22,483,587	3,529,573	26,013,160	33,817,160
1915–16	9,239,000	23,311,055	3,245,958	26,557,013	35,796,013
1916–17	7,569,000	25,166,401	3,732,560	28,898,961	36,467,961
1917–18	8,040,000	9,337,323	9.205,421	18,542,744	26,582,744
1918–19	11,674,000	16,914.802	5,669,699	22,584,501	34,258,501
1919–20	8 665,000	23,788,589	3,771,684	27,560,273	36,225,273
1920–21	7,112,000				

THE WHEAT CROP OF THE WORLD

EXPRESSED IN THOUSANDS OF QUARTERS OF 480 lbs.

Country.	1920	1919	1918	1917	1916	1915	1914	1913	1912	1911	1910
Austria	*2,300	*2,020	2,090	1,950	5,500	8,000	7,500	8,600	8,900	7,500	7,500
Hungary	4,300	4,000	3,500	14,000	17,000	21,500	16,500	21,000	23,000	24,000	22,700
Belgium	1,130	1,230	750	1,000	500	1,000	1,700	1,900	1,900	1,800	1,550
Bulgaria	5,530	4,250	3,170	3,500	5,000	5,800	3,700	6,600	7,000	8,500	7,100
Denmark	750	740	750	540	750	900	700	500	450	500	550
France	28,800	22,240	28,110	17,760	26,870	32,100	38,200	39,900	41,800	40,300	31,500
Germany	9,960	10,400	11,300	13,000	18,000	20,000	18,300	21,400	20,000	18,700	17,700
Greece	1,300	1,560	440	500	600	600	700	700	700	750	650
Holland	650	750	630	440	500	750	650	600	700	700	550
Italy	18,500	21,200	22,900	17,530	22,100	21,500	21,150	26,100	20,800	24,000	19,200
Portugal	950	910	1,000	940	870	700	900	800	800	1,000	800
Rumania	7,000	6,340	2,310	—	9,830	13,600	5,800	10,300	11,100	12,500	13,400
Russia	—	—	—	—	86,460	130,000	101,000	119,500	90,500	67,000	102,800
Serbia	†6,000	6,380	500	750	1,000	1,500	1,200	1,500	1,700	1,900	1,650
Spain	19,000	16,740	16,960	17,660	18,960	17,000	14,500	13,900	13,700	18,500	17,200
Sweden	1,340	1,190	1,120	860	1,130	1,000	900	1,100	900	1,000	900
Switzerland	450	440	820	570	480	500	400	450	400	500	350
United Kingdom	7,112	8,670	11,620	8,040	7,570	9,000	7,800	7,100	7,100	8,000	7,200
Total for Europe	115,072	109,060	107,970	99,040	223,120	285,450	241,600	281,950	251,450	237,150	253,300
Algeria and Tunis	2,250	4,110	7 210	4,500	4,540	5,700	3,500	5,300	3,000	5,500	5,700
Argentina	23,069	26,760	23,070	27,320	10,030	24,000	22,000	14,000	21,000	20,700	18,200
Australasia	19,455	6,580	10,620	16,240	19,520	24,200	3,800	13,500	12,000	9,900	13,100
Canada	33,000	24,160	23,620	29,220	27,550	42,000	19,800	29,500	28,000	27,000	18,700
Chile	2,500	2,700	3,000	3,000	2,000	2,000	2,100	2,000	2,500	2,200	2,300
Egypt	3,420	4,200	4,070	3,730	4,570	4,900	4,100	4,000	3,600	4,700	4,000
India	47,100	35,000	27,450	47,430	39,700	47,900	39,300	45,300	45,800	46,300	44,600
U.S.A.	98,730	117,620	114,640	81,350	79,990	126,000	111,400	95,400	91,000	78,000	79,400
Uruguay	900	680	870	1,600	800	1,200	1,000	700	1,200	1,200	1,300
Japan	3,100	3,720	3,900	4,340	3,760	2,900	2,700	3,000	3,000	3,100	2,700
Total out of Europe	233,524	225,530	238,450	218,730	192,460	280,800	209,700	212,700	211,100	198,600	190,000
Grand Total	348,596	334,590	346,420	317,770	415,580	566,250	451,300	494,650	462,550	435,750	443,300

* Including Czecho-Slovakia. † Including Yugo-Slavia.

CHAPTER II

WHEAT ANALYSIS

A GRAIN of wheat is, in simple language, a fruit, containing within itself the germ, or embryo, both of which are carefully wrapped up in a tough outer covering called the bran. The fruit, or flour, is the food provided by Nature to sustain the young plant. When moisture is applied to the grain it sets up a chemical action that changes the flour into a food suitable for the young plant, and on this food the germ feeds till it has developed roots and leaves sufficient to extract the nourishment it requires from the earth and the atmosphere.

The following is the physical structure of a grain of wheat with the approximate percentage of each part—

The epidermis, or outer skin . . .	0.5%	of the	grain
The epicarp, or second skin . . .	1·0%	,,	,,
The endocarp, or third skin . . .	1·5%	,,	,,
The testa, or fourth skin	2·0%	,,	,,
The embryo membrane	3·0%	,,	,,
The germ, or embryo	2·0%	,,	,,
The endosperm, or flour	90·0%	,,	,,

The first three skins may be taken to be simply protective coverings for the rest of the berry. The testa is the layer containing the colouring matter determining whether the wheat is white, red, or yellow. The embryo membrane, attached to the germ, envelops the endosperm and acts as the conveyor to carry it in the form of food to the young plant. Chemists estimate the endosperm as 90 per cent. of the berry, but that does not mean that it is pure flour, for the grain is composed of numberless particles which when ground become flour ; but there is a tissue running between the particles which might well reduce the percentage of actual flour to 85 per cent. Naturally some wheats are much thicker skinned than others, and it may well be that a large grain of wheat does not take as large a covering, proportionately, as a smaller one.

In any case there is a considerable difference in the percentage of flour contained in various wheats, and there is moreover much irregularity in the chemical constituents of wheats, much depending on the variety grown and the place of its growth. Wheat, roughly, consists of the following—

	Water.	Starch.	Proteids.	Oil.	Cellulose.	Ash.
General Average of Wheats . . .	14	66·3	14	1·3	3·3	1·4
American Spring .	11	64·5	16·6	2·5	3·3	2·1
Odessa Ghurka .	12·2	66·5	15	1·7	3·2	1·4
English Mixed . .	16·5	66	12	1·5	2·5	1·5
White Indian . .	11·5	69	12·5	2	3	2

The above table is an indication of the chemical constituents of wheat ; but other analyses of the various types give different results, and this is hardly to be wondered at, considering, in the first place, how hygroscopic the grain is, and, in the second, under what wide ranges of climate and soil it is grown.

It need hardly be pointed out how much the moisture content is subject to the harvest weather.

Thus, in 1915, a very wet harvest season, 678 tests carried out by the American Grain Standardisation Bureau gave the average amount of moisture in American winter wheat as 14.2 per cent., the actual percentage in the samples tested ranging from 10.6 per cent. to 19.3 per cent.

Starch, or carbo-hydrates, forms the chief part of the body of the cereal.

The Proteids, or nitrogenous matter, are the most valuable part, and at one time it was supposed that the wheat containing the largest percentage of this in the form of gluten was the strongest ; but of late years research has shown that it is more the quality than the quantity that counts. Both quantity and quality can be tested very easily by weighing a small quantity of flour, making it into a stiff dough, and washing the starch out by working the dough in the fingers under running water. When the starch is washed out, and the water runs clear, the gluten will remain in the fingers, and by weighing it the percentage can be ascertained. Good gluten has a large degree of elasticity, and will stretch considerably without breaking, while poor gluten is soft and sticky, with little or no toughness.

Gluten consists of two bodies known as gleadnin and glutenin, the first acting as the binding and toughening agent ; and probably the relative proportions—which vary considerably in different wheats—of these two substances determine the quality of gluten.

Oil, or fatty matter. The quantity of this in wheat is not a very important element. A great proportion of it is contained in the germ and bran, and is thus removed in milling.

Cellulose, or woody fibre, is contained chiefly in the bran and has no food value, being provided by Nature as a protection to the wheat berry. The percentage varies somewhat considerably, thin-skinned wheats having less than thick-skinned sorts ; and generally the thin-skinned are the better quality of the two.

Ash represents the minerals present in the wheat, which contains a trace of the following : Potassium, sodium, silicon, iron, magnesium, sulphur, phosphorus, calcium. The other elements which go to make up a grain of wheat are carbon, oxygen and hydrogen (in the form of moisture). The last named form nearly all the weight of the grain.

Germ differs in its composition in a most remarkable way from the other parts of the grain. Jago gives its analysis as follows: Water, 13.23 per cent.; ash, 4.94 per cent.; starch, 33.78 per cent.; proteids, 29.24; oil, 12.03; dextrin, 1.24; maltose, 5.54.

Bran contains about 18 per cent. to 19 per cent. of cellulose and no starch. Most of the mineral matter is contained in the bran, but in such insoluble forms that it is useless to the human system, being quite unassimilable. For full details of the chemistry of wheat and flour readers are referred to Jago's *Chemistry of Bread and Flour.*

The two qualities most desired in wheaten flour are colour and strength. Strong flour will absorb more water in the doughing process, as well as making a large well-piled loaf of nice texture. Colour is, in milling parlance, freedom from brownness. In some parts of the Kingdom a dead white loaf is required, in others a creamy tint is preferred. So generally is a white loaf demanded that an electrical tinting process is often employed, and a description of this will be found in a later chapter. White wheats, as a rule, yield whiter flour than red wheats, but much depends on the quality of the cereals themselves. Bombay White Wheat produces perhaps the whitest flour of any. Californian yields flour of a decidedly creamy colour. Bran particles discolour the flour, and are a sign of bad milling. Brown breads are made of wholemeal, that is, the wheat is ground but the resultant meal is not sifted, so that the bran and germ are left in. Analysis shows that there is food in the bran; but tests carried out on human beings have proved that the human system cannot assimilate the nutriment in the bran, and that, moreover, the presence of the bran prevents the complete digestion of the flour. Further experiment has demonstrated that the less fibre, or bran particles, left in the flour, the more nutriment the human system obtains from the bread made of it. Wholemeal bread doubtless possesses a medical value of a mechanical sort that is beneficial to some people; that is, the bran acts as an irritant to the bowels in the same way as a mild aperient. There are, in addition to the ordinary brown meal, many patent meals that are more or less in vogue with a certain section of the public, who find that they suit their palate, or they fancy they suit their systems, as in some cases no doubt they do. As a rule, however, people soon tire of fancy breads and revert to the ordinary white household variety. That this is so is more than proved by the early death of "standard" bread. Not even the *Daily Mail*, which boomed it, could persuade the public to eat it for long; and the public was wise, for it contains less nutriment than white bread.

One peculiarity of wheat which distinguishes it from all other cereals is the crease, which nearly divides the grain in half lengthways. Other grains, like rice or barley, can be decorticated, or pearled; that is, the outer skin or husk can be taken off, leaving the endosperm whole, which can then be ground into flour. It is, however, impossible to scour the bran off wheat owing to the crease, so that the whole berry has to be ground up, and the bran sifted out to obtain the flour.

WHEATS, THEIR COLOUR, STRENGTH, AND IMPURITIES.

Wheat.	Colour.	Strength.	Impurities present.	Occasional impurities.
American—				
Western Winter .	Red	Fair	Cockle, seeds, oats	Peas, garlic, smut, barley
No. 1 Northern Spring	,,	Strong	Cockle, oats, seeds	,, ,, ,,
Durum	,,	,,	,, ,, ,,	,, ,, ,,
Walla Walla . .	White	Medium	Chaff, straw, oats	Smut, dirt, stones
Blue Stem . .	,,	,,	,, ,, ,,	,, ,, ,,
Californian .	,,	,,	,, ,, ,,	,, ,, ,,
Canadian—				
No. 1 North . .	Red	Strong	Cockle, seeds, oats, barley	Peas, dirt, stones, frosted-grains
Manitoba Winter .	,,	Medium	Cockle, barley, maize	Smut, dirt, stones
Argentine—				
Rosa Fe . .	,,	,,	Black oats, barley, seed, dust, light grains	Smut, dirt
Buhia Blanca .	,,	,,	,, ,, ,,	,, ,,
Santa Fe .	,,	,,	,, ,, ,,	,, ,,
Chilian	White	Poor	Grass seeds, chaff, stones	Oats, barley
Russian—				
Arima (Winter)	Red	Strong	Oats, barley, rye, dirt	Smut, stones
Ghurka (Spring)	Red	Strong	Oats, barley, seeds, rye	Smuts, stones
Tagaurog . . .	Yellow	,,	,, ,, ,,	,, ,,
Kubanka .	,,	,,	,, ,, ,,	,, ,,
Saxonka . . .	Red	,,	,, ,, ,,	,, ,,
Indian—				
Bombay . .	White	Medium	Stones, dirt, linseed gram	Oats, weevil, barley
Bombay .	Red	,,	,, ,, ,,	,, ,, ,,
Karachi. . .	White	,,	,, ,, ,,	,, ,, ,,
Karachi. . .	Red	,,	,, ,, ,,	,, ,, ,,
Calcutta . ..	White	,,	,, ,, ,,	,, ,, ,,
Delhi .	,,	,,	,, ,, ,,	,, ,, ,,
Australian . . .	White	Fair	Chaff, short straw	Oats, barley, seeds
New Zealand .	,,	Medium	,, ,, ,,	,, ,, ,,
English—				
Rough chaff .	White	Mild	Chaff, screenings	Seeds, oats, smuts, dirt
Essex white . .	,,	,,	,, ,, ,,	,, ,, ,,
Square Heads Master	,,	,,	,, ,, ,,	,, ,, ,,
Red Lammas . .	Red	Good	,, ,, ,,	,, ,, ,,
Rivetts	,,	Weak	,, ,, ,,	,, ,, ,,
Nursery. . . .	,,	Good	,, ,, ,,	,, ,, ,,
Burgoyne's Fife .	White	Strong	,, ,, ,,	,, ,, ,,
Red Fife . . .	Red	Strong	,, ,, ,,	,, ,, ,,

CHAPTER III

ANCIENT MILLING

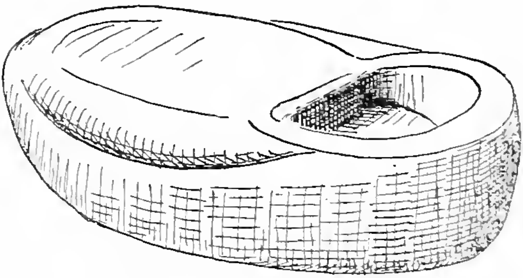
When man first discovered the art of reducing, or grinding, wheat into meal is, like the origin of the cereal itself, quite unknown; but the oldest pictorial and other records that are discovered from time to time indicate that the art, in a crude form, was practised by the nations of antiquity.

Probably the earliest method was to pound the grain with a stone; and later a hollow stone was used as a base, and the grain pounded with a pointed stone, on the pestle and mortar system. There is evidence of this simple method being used by the Romans as late as A.D. 79. Milling is so often mentioned in the Bible, and so important was the means of reducing flour to meal considered, that the Mosaic law forbade anyone to take a millstone in pledge. The Jews certainly used two round stones, or a *quern*, to grind their grain, one stone being made to revolve upon the other. The earliest authentic history of milling was in Abraham's time, when he told Sarah to prepare fine meal for the angels, though it is apparent that it was, even then, an old art, and the grinding of grain was part of woman's daily work. Presumably Sarah used some sort of a sieve to make the *fine* meal from the ordinary meal, and we are told in the Bible of flour, fine flour, and the finest wheat-flour, so that there were, apparently, sifting appliances and grades of flour even in those days, and the finest flour was doubtless reserved for the head of the family and honoured guests, while the servants and slaves used the coarse meal.

Egyptians doubtless advanced the art of milling, for their civilisation was far ahead of that of any other country of the ancient world. In hieroglyphics, on stone, are to be found representations of grinding grain, and sifting the flour from the husk, or bran, with hand sieves. When the Israelites fled from Egypt, they doubtless carried their mills with them, as well as the kneading-troughs, which are mentioned in Exodus. Manna had to be ground, for it states in Numbers xi. 8: "The people went about, and gathered it, and ground it in mills, or beat it in a mortar, and baked it in pans and made cakes of it." The art of grinding seems to have come only from the East, as there has never been found amongst the Aborigines of Australasia any trace of a grinding device. Neither is there any evidence of the American Indian having had any idea of grinding Indian corn. The *quern*, or hand-mill, was introduced into Europe at an early date, for there is evidence that Gauls and Early Britons used them before the Roman invasion. This style of milling is estimated to have been in use for at least 4,000 years. Evidently there were inventors even in those days who tried to provide a better means of milling than the *quern* afforded, and the following sketch of a statuette in limestone in the Cairo Museum shows a woman grinding with a roller mill over 5,000 years ago. Such a mill was recently found in the priest's house connected with the temple of the tomb of the fifth dynasty Pharaoh, Nefer-Ar-Ka-Ra (according to Professor Flinders Petrie about 3660-3680 B.C.) at Abusir. The lower stone is about 2 ft. long by 18 in. wide. It is of red sandstone, and is now in the Berlin Museum.

Unfortunately the upper stone is missing; but it appears to have been a kind of roller between which, and the smooth surface, the corn was ground, and the meal would probably be pushed into a receptacle at the end. There are two shallow half-moon shaped recesses on either side of the plain surface, and these may also

ROLLER MILL, 5,000 YEARS OLD



ANOTHER VIEW OF BEDSTONE

have been intended to receive the meal, or maybe they were for the knees of the operator to rest in.

Following the *quern*, the slave and the cattle-driven mills made their appearance. These, with continuously running stones, were probably the direct parents of the millstone, as it was known up to late in the nineteenth century, and as, indeed, it is still used for other purposes than wheat grinding.

The Greeks seem to have been the inventors of power-driven corn mills, and the water-mill. The water-mill, such as it was, appears to have been a kind of boat anchored out in the stream, the water-wheel being pushed round by the natural flow of the water, and probably the stone ran very slowly. The Romans improved on this, and probably constructed the first mill-dams, to obtain a head of water at one point, to drive the wheel; but there seems to be no record of the date of this invention.

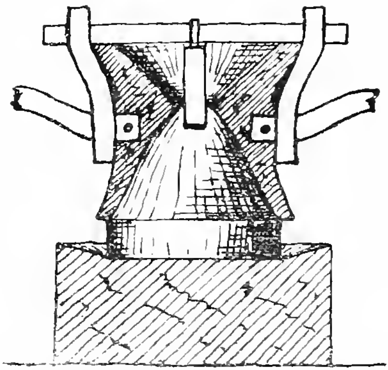
HORSE-DRIVEN MILL

Public water-mills are mentioned in the Roman laws of 398 B.C., but it is questionable if there were many of them at that date; and there is no evidence of power-driven sifting machines. These water-wheel mills were introduced into Britain by the Romans, and doubtless one was erected at each of the Roman camps. It does not appear that anyone thought of building a large water-wheel to drive several pairs of stones till late in the eighteenth century.

In Doomsday Book hundreds of mills are mentioned, and were obviously considered to be of great value to the owner. There were very stringent laws, about that time, compelling the people to have their corn ground only at the mill of the lord of the manor.

The Dutch probably built the first windmills, and this is easily understood when it is remembered that there are few rivers in Holland, and that the country is flat, giving small fall to the rivers. It was largely owing to the latter reason that windmills were originally so common in the fen country on the English East Coast.

John Smeaton, a famous old Yorkshire millwright,



SECTIONAL VIEW OF HORSE-DRIVEN MILL

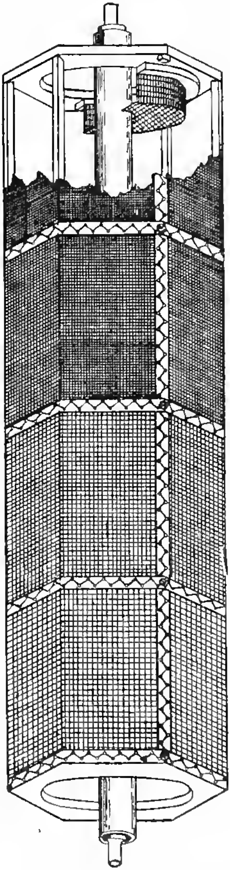
introduced many improvements in mill gearing and driving. It was in a mill near Wakefield that he first introduced spur-gearing, under the millstones, to drive several pairs at once from the one large spur-wheel—an entirely new application of this simple device. He was also the first to advocate the use of a steam-engine to drive flour-mills, in a letter dated 23rd November, 1780, addressed to the British Government.

The Albion Mills, London, situated near Blackfriars Bridge, are supposed to have been the first steam-mills erected. Built in 1788, they were destroyed by fire a few years later. They were looked upon as a monopoly, dangerous to the public interest; but it is said that they reduced the price of flour in London. Cast iron wheels and shafting were introduced into these mills instead of wood. Wooden shafts, both horizontal and vertical, are still to be found in the old country mills, looking like revolving trunks of forest trees.

Millstones, as used for wheat-grinding up to the latter part of the nineteenth century, had changed but little since the third century. The upper, or runner, stone of the pair, carried on the vertical spindle, was made to rotate over the lower, or bed stone. The wheat was fed into a hole in the centre of the runner and carried through between the stones by centrifugal force, assisted by the furrows cut in the faces of the stones. It was ground on its way to the periphery, and there discharged and collected. The stone used was French Burr from quarries in Champagne, France. The name of the man who invented furrows is lost in antiquity; but some sort of dress must have been invented as soon as stones were driven mechanically, and so ran more or less continuously.

To all practical purposes the millstone is out of use to-day, as far as wheaten flour manufacture is concerned; but it is still largely used for grinding maize, barley, and other grain, as well as minerals and other material.

In the days of the stone-mill mechanical sifters were utilised for separating the bran or husk from the flour. One of the best known at one time was a wire-covered cylinder set at an angle of 45 degrees. Inside the cylinder, and fixed to a revolving shaft, were four brushes, each the length of the cylinder. The meal was collected from the stones in sacks and allowed to stand for perhaps a few days. It was then fed into the top end of the cylinder, and the revolving brushes forced the flour through the wire mesh with which the machine was covered. This machine was called a "bolter," and hence we got the word "bolt" flour, which was used up to quite a recent time when the term to "dress" flour became usual; and modern flour-sifters are collectively spoken of as dressing-machines here, though in America the old English name of bolter is still in common use. Following the wire-covered bolter came a textile-covered machine, invented by Blackmore, and called Blackmore's bolting-reel. This was a hexagonal-shaped reel, covered with a woven worsted cloth, and can be found still in many country mills. No force was used inside the reel, the flour being sifted through the cloth by the shaking action of the revolving reel.



FOUR-SHEET HEXAGONAL REEL

The old wire bolter may be said to have held the field till the introduction of silk bolting cloth from the continent, about the middle of the nineteenth century. Long hexagonal reels were then invented, and on the arms forming the reel the silk was laced tightly.

This silk bolting cloth is woven one metre wide, and, since it came into general use, all mill-dressing reels have been built so many metres long, so that none of the silk might be cut to waste.

Machines of this class are still spoken of by the number of sheets of silk that are required to clothe them from end to end. The old hexagonal reel was made six or eight sheets long; and, as the mesh of the silk was much finer than the old woven wire, the dressing of the flour, *i.e.*, the separating of the flour from the bran, was done much more perfectly. Silk has never been superseded by any other material for sifting in modern flour-milling.

Sir William Fairbairn was the man who, perhaps more than any other, left his mark on flour-mills of the old type. He brought millwright work to a high state of perfection. His millstone fittings, gearing, etc., were far in advance of anything that had previously been seen in any corn mills. He was responsible for the marvellous improvements that, starting earlier in the century, had removed so much of the heavy, cumbersome gearing and shafting from British mills, and replaced it with well-designed and balanced appliances for transmitting power. Others, of course, followed his example, so that the latter mills of the stone period were triumphs of engineering skill. The final revolution in flour-milling in England really began in 1881. Flour superior to the home-made article was being poured into the country from Hungary and America. British millers began to feel that something was wrong. The talk was of rollers, and the trade papers were full of the subject. Improved dress for millstones was advocated, and tried. Diamond stone-dressing machines were introduced. Some few millers had been looking into the matter; but 99 per cent. believed that only stones could grind wheat properly, in spite of the fact that Hungarian flour, which was capturing the best trade was made on rollers. A few smooth rollers were introduced to soften middlings, which had hitherto been reduced on stones, or sold for making ships-biscuits and things of that class. Purifiers were invented to extract the bran particles from the middlings, to enable them to be ground to better advantage on either stones or rollers.

All this was so much time and money wasted; and yet, perhaps, not totally wasted, for all the intermediate systems were part of the evolution that led to the roller mills of to-day. The first roller mills appear crude now to those who remember them. They were not automatic. Partly finished products were sacked off, and shot on to other machines to be finished, as convenient.

The year 1881 will always be remembered in the trade as that of the great exhibition of improved milling machinery which was held in London. A number of complete mills were erected, and shown at work, in the Agricultural Hall at Islington. Even then, so great was the difference of opinion as to the advantage of rollers, that stone-mill builders exhibited stones and stone dressings with which they undertook to extinguish the hopes of the roller-mill men. The millstone, however, as a flour maker, had had its day, and had to give way to fluted iron rollers; and the roller system came like an avalanche and swept all the old methods away. At one time in the 'eighties millers seemed to care less about the cost of a roller plant than the speed with which it could be installed, as their competitors who had changed their system before them were carrying off all the trade. The country was at the same time being inundated with flour from America, whose millers said, and thought, they were going to capture the trade and put British mills out of use.

The decrease in the imports of American flour of late years, and the success of roller milling, shows how the British millers fought, and defeated, the attempt to put them out of business.

The full history of the evolution in the manufacturing side of flour milling during the last fifty years would require several large volumes to record it ; so it must suffice to say that the essential differences between the old and new method were the introduction of the middlings purifier, and the substitution of iron rollers for stones. The dressing system is much the same in principle, though improved in detail. Milling is, first and foremost, grinding. With stones the grinding was done with one operation : with rollers it is a system of graduated reduction.

CHAPTER IV

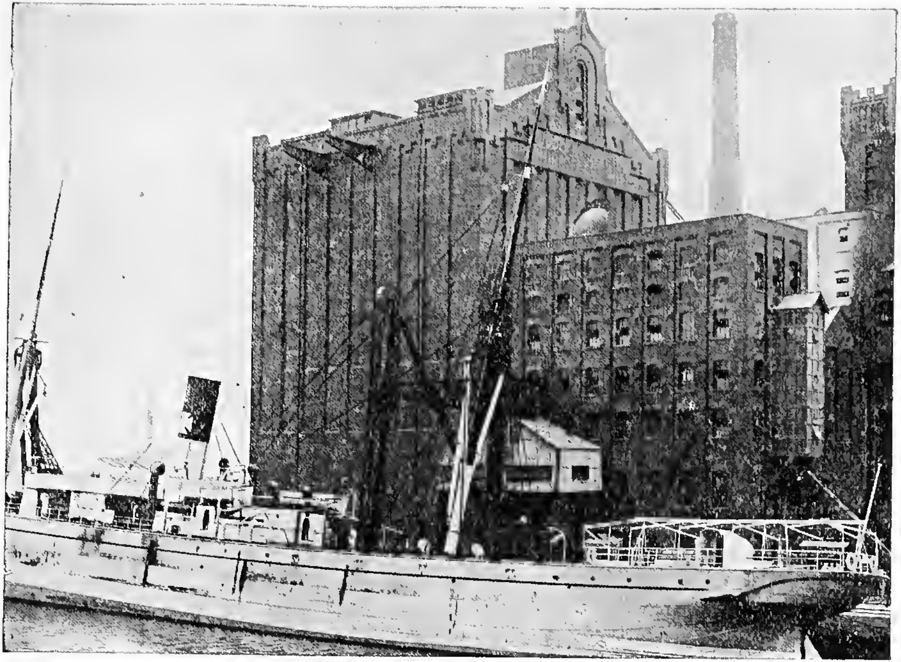
SILOS

UNTIL comparatively recent times, wheat was all received into the mills in sacks. Often it arrived alongside the mill in bulk, but when this was the case it was sacked up in the boats, and hoisted into the mill by means of a chain sack-hoist.

In the pre-roller days there was very little actual machinery in the mill, and in most cases the one building served as mill and storehouse for the wheat, and for the finished products. In a few of the more modern stone mills there was a separate warehouse, but this was not general. Automatic handling of grain was not thought of, and sacks of wheat were hoisted into the mill by a sack-hoist and trucked by men to where they were required, and often stacked up one on top of the other. Then when a mixture had to be made for grinding, so many sacks of one sort, and so many of another, were shot, just as required, into a bin, and from there run over the wheat-cleaning machines and so into the bins over the stones. When the roller process was introduced, the dressing machinery, purifiers, etc., occupied so much of the mill proper, that warehouses had to be built for the ground and unground products.

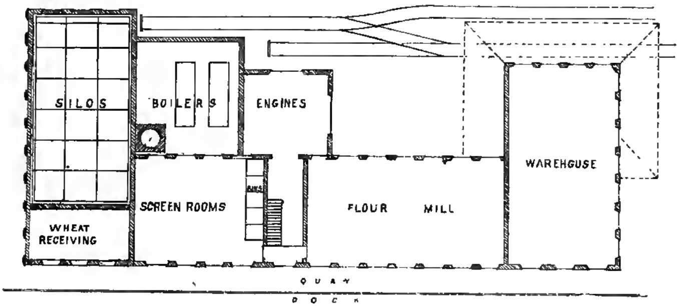
The wheat-cleaning machinery was perhaps the first section to be given a department to itself. This was almost invariably over the engine-house : the engine, of course, required only the ground floor, and the two or three floors above were used for the wheat-cleaning machinery, and are so used in many mills to-day.

When larger mills became the order of the day, fire insurance considerations demanded separate buildings,



THE SILO HOUSE OF A PORT MILL

(Ship's Elevator installed by Spencer & Co. Melksham) both as a means of reducing the premiums and to obtain greater security from fire ; but even then only ordinary warehouses were at first built, and it was not till later that the bulk storage of wheat was introduced, and the modern silos built. These silos are the storage for only, what is termed, dirty wheat, though, as a matter of fact, the wheat is always roughly cleaned before being stored in them. The bins for cleaned wheat are generally in the wheat-cleaning department, and are dealt with in connection with the wheat preparing system. If not



GROUND PLAN OF MODERN PORT MILL

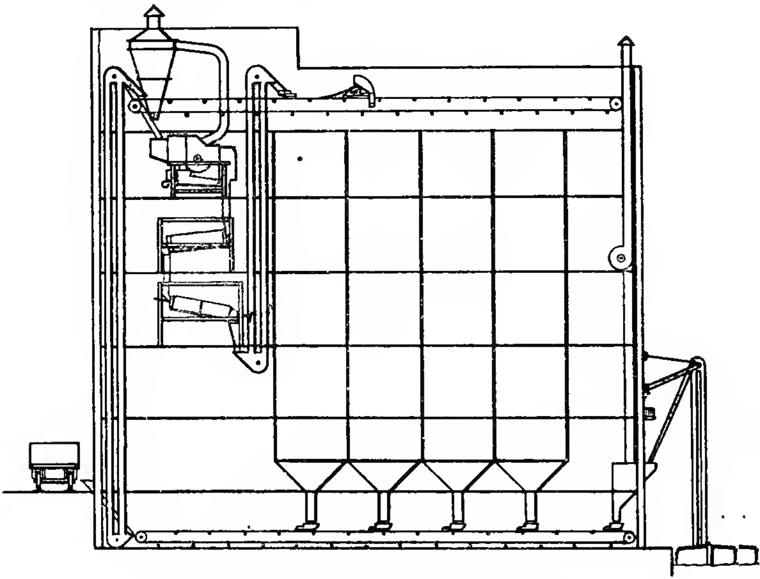
in the actual wheat-cleaning room, these intermediate bins are often in a separate block adjacent to the screen rooms.

Probably the modern silos originated in North America, where they go by the name of elevators, and are not necessarily in connection with flour-mills, being established at various points all over the States, and Canada, for the reception of wheat from the farmers, whence it is passed on in bulk railway trucks, or by water, to milling centres, or to the ports for shipment.

The sketch shows one of the latest mills that have been built, but there is no rule as to the position of the various buildings : it all depends upon the site available. In many cases the mill had been built first, and warehouses and silos added, in which case the mill was originally mill and warehouse, and built alongside the rail, or canal, so that the other buildings had to be placed where space was available, and are not as convenient for getting stuff in and out as they might be. Naturally the silos and warehouses should be nearest the transport facilities, and the mill in the background, as one might say.

Silos are usually built of brick, ferro-concrete, or steel. When bricks are used the actual silo bins are usually made of timber, with strong steel-plate hoppers. These hoppers are carried on girders supported on sufficiently strong pillars resting on a solid foundation of either brick or concrete ; and the foundation must be well up to the total weight to be carried, which is enormous when the bins are all full. The weight of the contents is easily arrived at when it is remembered that a quarter of wheat occupies about $10\frac{1}{4}$ cubic ft., and that a cubic foot of wheat weighs about 47 lb. Thus, suppose the bins are 10 ft. $\times$ 10 ft. square, and 60 ft. deep, they have a capacity of $10 \times 10 \times 60 = 6{,}000$ cubic ft., $6{,}000 \div 10\frac{1}{4} = 585$ quarters and add, say, 5 qrs. for the hopper = 590 qrs. = about 130 tons.

Often, on the sides of rivers and docks, it is necessary to drive piles to get a foundation, and ferro-concrete piles are now generally used and are far the best, as they are practically everlasting. In addition to the dead weight there is also the lateral pressure of a bulk of wheat, for the angle of rest of a heap is only some 30 degrees, and so the pressure of the grain on the sides is very great, especially at the lower part of the bin when this is full. Many of the early silos burst and collapsed from this lateral pressure, which increases as the wheat settles down naturally and from vibration. When silos-houses are built of brick they are lined with criss-cross timbers, making solid timber walls, and taking all the strain off the brick walls, which only act as a protection from the weather, and carry the roof. Starting with a concrete base and floor, on the four sides of this the walls are built, and, at the points where the corners



WHEAT SILOS AND INTAKE PLANT

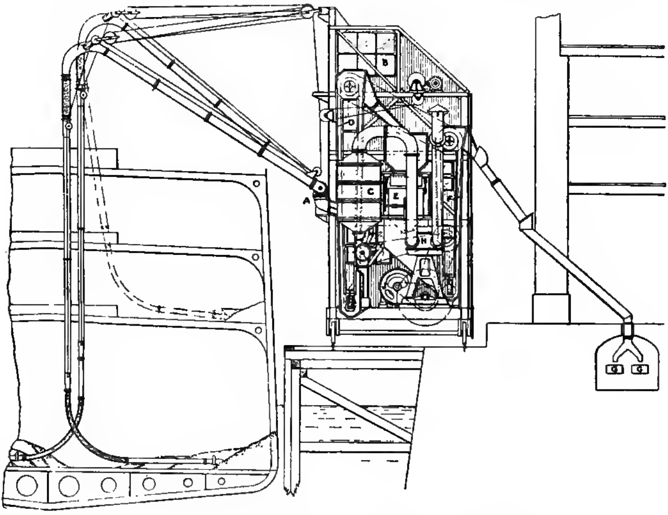
of the bins come, stout iron pillars are placed. Across these pillars are laid girders, the extreme ends of which are built into the brick walls. Hanging down from the girders are the sheet-steel hoppers which form the bottoms of the bins, and also act as funnels for leading the wheat to the spouts which form the exit for the wheat.

On the girders are built up the timber structures which form the actual bins. These timbers may be 6 in. × 3 in. at the bottom of the bins where the pressure is greatest, and the width or thickness of wood work is reduced gradually till at the top they are only 2 in. wide. These planks are notched wherever they cross to allow them to form a solid wall. The ends, and points of intersection, are thoroughly spiked together, and thus the walls are built to any required height. It must be remembered, however, that timber shrinks and swells, so these bins must not rest against the walls, but there should be a space of, say, 6 in. all round between the outside walls and the bins. Again, the floor above the bins should not rest on top of them, but be carried on joists or beams from outer wall to outer wall in the usual way, with a few inches clearance between the floor and the top of the bins. In some cases it is more convenient to have the wheat receiving and preliminary cleaning apparatus in the screen room, and the silo building entirely bins ; in which case it is usual to have one bin space, at one end of the building, vacant, and up this run the wheat elevators and the staircase, or an operatives' elevator. Along the top of the bins is a conveyor band to take the wheat from the elevator and distribute it to the bins as required. Another and more usual plan is to have the receiving house (containing automatic weigher and preliminary cleaning machine) attached to the silo.

Pneumatic Elevators.—The pneumatic elevator is the most modern appliance for transporting grain from the boats to the silos, and it may be as well to deal with this type of elevator first.

It consists of a fan, or an air-pump, a discharger, a dust collector and the necessary piping.

The air-pump, or fan, and the other mechanical parts can be fixed inside the building, and the intake pipe carried down, or out, to the grain to be handled. The air-pump creates a vacuum which causes a rush of air inward through the pipe. The intake nozzle is attached to the pipe by means of a flexible metallic tube, which allows it to be inserted in the grain in any part of a ship's hold, and moved about at will. The suction draws the grain into, and through, the pipe till the



SIMON'S PNEUMATIC GRAIN ELEVATOR

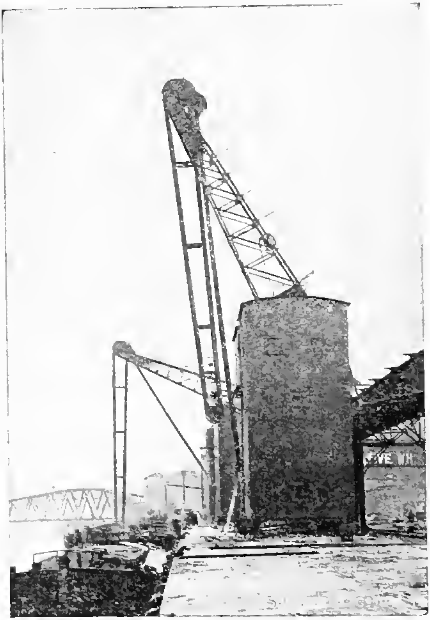
discharger is reached; there it is deposited, while the air and dust pass on into a dust-catcher where the dust is separated from the air, which then reaches the vacuum pump which in turn delivers it to the open atmosphere. The grain is delivered from the discharger by means of a mechanical appliance which prevents air entering while allowing the wheat to pass out. Any air entering otherwise than at the end of the nozzle would pass direct to the pump without lifting the wheat. The dust-catcher, or dust-filter, is in an air-tight case so that only air drawn through the pipe can reach it. The power required is from one or two horse-power per ton of grain transported per hour. The actual power required depends largely on the distance the grain is lifted and carried.

One of the greatest advantages of a pneumatic elevator is that it can unload any number of parcels of grain out of a ship with little difficulty.

It is becoming daily more general for ships to arrive with small parcels of grain, and this renders the question of the speedy, and efficient, discharge of the cargo a far more difficult problem than is the case with ships carrying one large consignment.

These small parcels are often only divided by mats, or cloths, and are often one on top of another, so that it is impossible for a bucket elevator to pick up the grain without a great deal of hand-trimming, whereas the nozzle of a pneumatic elevator can be moved into all the odd corners of the hold, and will pick up the grain without disturbing the mats. If it requires more power than a bucket elevator, it saves the cost in manual labour. These appliances have been very considerably improved, and take much less power than the earlier ones, and are being still more improved in this respect. One advantage is that they raise no dust in the holds ; in fact, they take up the dust with the wheat and act as a preliminary aspirator. When used in docks the dust from the dust-collector can be run back into the bulk. Of course, the miller does not want the dust, once it is extracted, mixed back in, but in this case it can be sacked off from the dust-collector, and weighed to ascertain that the total weight of the parcel is received.

The difference in power required to operate a belt and bucket elevator as against a pneumatic elevator is difficult to arrive at, as they generally work under different conditions. If it takes 1 h.p. to raise 33,000 lb.



SPENCER'S BARGE-DISCHARGING ELEVATOR

1 ft. in a minute, it obviously takes 1 h.p. to raise 1,000 lb. 33 ft., and in either elevator some allowance must be made for wastage, friction, etc. The pneumatic elevator, however, acts as a conveyor as well as an elevator, and the intake pipes can be laid underground, or carried overhead, with but slight support,

and can, without loss of efficiency, be carried round awkward corners. Probably it requires nearly as much power to carry the grain horizontally as vertically.

Barge Elevators.—A barge elevator of the belt and bucket type is usually attached to the building in such a manner that it can be lowered into boats alongside

SPENCER'S SHIP-DISCHARGING ELEVATOR.

the mill, or silo, when required to unload the vessel, or raised up out of the way when not in use. The elevator is supported on a jib by means of spring hinges which are sufficiently flexible to prevent damage from any side movement which might be caused by the boat shifting.

The elevator discharge is connected to the building by a telescopic spout—which allows for raising and lowering the elevator—down which the wheat flows to another elevator inside the building.

A ship-discharging elevator is often mounted on a travelling structure, which can be moved along the quay side, when necessary, to reach the ship to be unloaded. In this case a counter-weight on a beam balances the weight of the elevator.

The capacity of this type of elevator entirely depends on the size of the buckets and the distance they are apart on the belt. The endless belt to which the buckets are attached travels at a speed of about 300 ft. per minute. They are enclosed in two trunks, or legs, the full buckets travelling up the one leg and returning down the other empty. The bottom pulley is often smaller than the top one, so that fewer buckets are in the bulk of grain at one time than would be the case with a large pulley, which would have more buckets round the lower half of its circumference. The " boot " of the elevator is open at the bottom to allow the grain to flow into the buckets. All the remainder of the apparatus is enclosed to prevent waste of wheat spilled from the buckets. Often an exhaust fan is connected to the elevator to draw away the dust stirred up by the buckets, and to carry it to a dust chamber, or dust collector. A band conveyor is often required to carry wheat from a ship's elevator across, or under, the quay to the mill, or silo.

Indian wheats generally arrive in sacks which have to be lifted out of the vessels by means of chains, and their contents shot into an intake elevator. This, owing to the dirt in this sort of wheat, is about the most unpleasant job in connection with flour-milling.

Mills receiving grain by rail and farmers' waggons should have an intake elevator inside the building, with the boot low enough for the grain to be shot into it, through a spout, from the bed of the waggon.

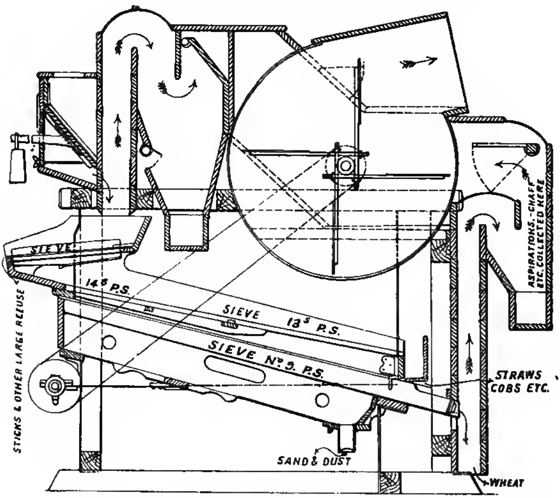
A small country mill requires an intake plant just as much as does a port mill, even if it only consists of an elevator to carry the wheat to the bins, as a considerable amount of labour can be saved. A sack-hoist, especially in a water-mill, is almost bound to affect the speed of the mill, unless driven by a separate motor, which is not often possible; while an elevator runs steadily without any jar or shock on being put in, or out, of gear.

The wheat from the intake elevator, of whichever type, is delivered into the receiving house and into an elevator of the bucket type. This carries the wheat up to the top floor of the building and delivers it on to an automatic weigher.

The automatic weigher tips its charge, when weighed, into a hopper. This is necessary, to ensure an even regular feed to the next machine, as the weigher delivers the wheat intermittently, it may be a few cwt. at a time, or even as much as three or five tons at a weighing, whereas the rest of the intake and preliminary cleaning machinery requires a continuously even stream of wheat.

Preliminary Cleaning.—From the hopper the wheat is fed to probably a rubble reel, or it may be to a warehouse separator for a preliminary cleaning. A rubble reel is often used because of its great capacity. It is often just an ordinary reel, but sometimes is built like a centrifugal reel without the beaters, *i.e.*, it is a reel carried on the outer rails, and without the centre shaft. The advantage of this is that having no centre shaft there is nothing for strings to hang round. With an ordinary reel strings will get wrapped round the shaft and the arms, and are most difficult to clean out, strings being found in most wheats. The first section of the rubble reel is clothed with fine mesh wire, or small hole-perforated steel, to let the dust and small grit through.

The second section is clothed with perforated metal with holes large enough to allow the wheat to pass through and small enough to tail over straws, strings, corn cobs, maize, beans, and large impurities of that



LONGITUDINAL SECTION OF ROBINSON'S WAREHOUSE SEPARATOR

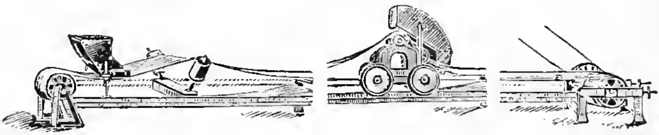
Showing Fan and Air Currents

description. The reel may or may not have an aspirating fan; generally it has not. The wheat can go from the reel direct to the silos, or be first passed through an aspirator, or a warehouse separator, to give it an extra preliminary cleaning. If no rubble reel is used a warehouse separator is employed.

Warehouse Separator.— The warehouse separator usually consists of a feed hopper, a feed roller, three sieves, and an exhaust fan. The feed hopper is fitted with an automatic feed gate which can be set to spread the feed all the width of the first sieve. As the wheat falls on the first sieve it is met by a strong, upward current of air induced by the fan and controlled by a valve, which latter must be adjusted so that the air current is strong enough to carry away dust and other matter lighter than wheat, such as smut balls, chaff, short straws, weevil-eaten grains, etc. The first sieve is a short one formed of rather large holed perforated zinc, which will let the wheat through freely while tailing over coarse impurities such as strings, long straws, corn cobs, etc. The second sieve, which is nearly as long as the machine, is of smaller holed zinc than the first, usually No. 14 perforated zinc, large enough to let the wheat pass through while tailing over impurities slightly larger, such as peas, beans, maize, large oats and barley, etc.

The wheat falls through the second sieve on to the third sieve. This is too fine to allow any wheat to fall through, say No. 8 zinc, and is for the extraction of small round seeds, small stones, sand and other impurities of this class. The wheat tailing over this third and last sieve is again subjected to a strong aspiration to further remove chaff, light wheat, dust, etc., detached, maybe, from the wheat grains in process of sifting. This final aspiration is controlled by a valve in the same way as the first. In both cases the air and dirt are carried through expansion chambers, and round deflecting boards, which cause most of the matter in suspension to be deposited, the air and light dust only passing through the fan, and thence to a dust-catcher, while the heavier impurities, which have been extracted by the air, fall through trapped spouts into sacks. The sieves have a reciprocating motion, driven by cranks from a shaft running across the front of the machine. The motion is, usually, in the same direction that the wheat travels, or, to put it in another way, the sieves move endways. This is not the invariable rule, as in some machines of this class the sieves have a lateral, or from side to side, movement which is claimed to be a more searching sifting.

The largest machines usually have the sieves in halves, and set to balance each other; that is, while one is moving back the other is moving forward, and while one is moving forward the other is moving back, the object of this being to prevent the vibration of the whole



SECTIONS OF CORCORAN BAND CONVEYOR

Showing Terminals and Putting-on and Throw-off Carriages

machine. It will be noticed that this machine makes separations by size and weight, removing dust and light impurities by air currents, and grading the heavier stock by means of sieves. It is now usual to exhaust all possible dust from the various spouts, etc., of the intake plant. Thus an exhaust is applied to spouts, elevators, automatic weighers, etc.

The wheat is spouted from the warehouse separator into an elevator that carries it up to the top of the silos and deposits it on a band conveyor. This runs the whole length of the top floor and high enough from the floor for the wheat to be spouted to the bins on the outer side of the silo block. A travelling throw-off carriage is provided, that can be set at any point along the belt, to deflect the wheat into any desired bin.

Under each bin is fixed a wheat-measurer which will draw out the exact proportion required from its bin; or a number can be working at once, each delivering a set portion from its bin. These deliver on to a belt, or worm conveyor, which carries the grain into a wheat-cleaning department, or, as it is generally called, "the screen room."

CHAPTER V

WHEAT CLEANING AND CONDITIONING

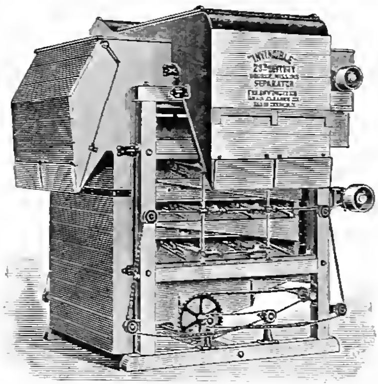
To make good flour requires, first, good wheat, and, second, only wheat, and clean wheat in good condition. A comparatively short time before the introduction of the roller system the screen room was actually what its name conveys, for in many cases a screen was the only machine used in the preparation of the grain. Then came the wheat scourer, which often went by the name of the smutter. In those days the importance of wheat-cleaning was not realised as it is now. The roller system made such an improvement in flour that for a time wheat-cleaning was left very much in the background. In fact, it was considered that roller milling rendered wheat cleaning less necessary: but, having brought the roller system a long way towards perfection, millers and engineers devoted more attention to what is still known as the screen room. Now it is well understood that the more thoroughly wheat is prepared for the mill the better is the resultant flour, and this being the case no expense can be spared to make the wheat-cleaning as perfect as possible. Dirt has been defined as "matter in the wrong place," so anything except wheat that goes to the first break roll is most certainly "matter in the wrong place." The machines used in wheat-cleaning are designed to remove all that is dirt from the wheat, and, as the dirt assumes many forms, a sequence of machines is required for its elimination. Matter larger, smaller, lighter, heavier, and of slightly different shape from wheat can be, to a large extent, separated from it by sifting and aspiration.

But impurities adhering to the grain have to be scoured and washed off before they can be eliminated. So much have the benefits of wet cleaning been realised that most millers wash all their wheat, be it soft or hard, dry or damp; for it has been found that sweated, clammy English wheat can be greatly improved by washing before any attempt is made to dry it. Russian, Indian and Persian wheats can only be cleaned by washing as they contain lumps of hard clay, stones, etc. There should be an automatic weigher to weigh the wheat received into the screen room from the silos. This will enable the miller to tell exactly how much weight is gained or lost in this department. The first of the cleaning machines is the milling separator. This must have a bin over it large enough to hold at least one charge of the automatic weigher, and the feed of the separator must be set to practically empty the bin by the time another charge is weighed and tipped into it. The weigher works intermittently while the feed works continually, so that there must be this small bin between to equalise matters. In many mills there are large dirty wheat bins in the screen room into which the wheat is sent as required from the silos, and from them conveyed to the milling separator direct.

Milling Separator.—One type of the milling separator is practically the same as the warehouse separator previously described, with the exception that the first short, coarse-meshed sieve is omitted, and the first long sieve is of smaller meshed perforated zinc, No. 12 as against No. 14 on the corresponding sieve of the former machine.

Another pattern is known as the Zig-Zag Separator from the arrangement of the sieves which carry the material backwards and forwards, dropping it from one sieve to another down a zig-zag course. These sieves invariably have a lateral movement which is claimed to give closer cleaning than the ordinary reciprocating movement. The matter removed by the milling separator is much of the same nature as that taken out by the warehouse separator, but the cleaning is more thorough and much dirt missed in the first instance is extracted here.

The first aspiration removes dust, chaff, smut-balls, light wheat, etc. The first sieve lets the wheat through,



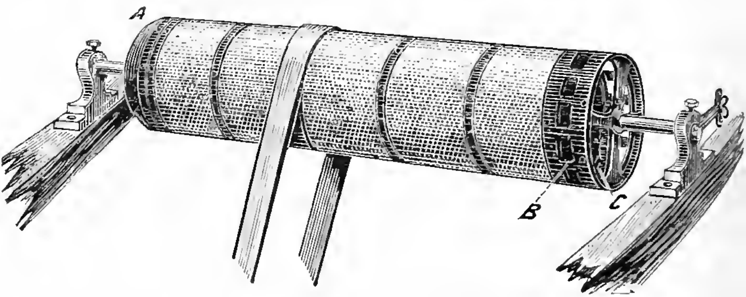
INVINCIBLE ZIG-ZAG MILLING SEPARATOR

tailing over peas, beans, maize, oats, barley, and stones, and lumps of soil larger than the wheat ; the second sieve of No. 8 perforated zinc lets through sand, round seeds, and stuff of this class, the wheat tailing over and being aspirated for the second time. This aspiration removes chaff and other matter that has been loosened from the grain in the friction of the sifting, also light grain that has been missed in previous aspirations.

The next step in the cleaning is rather difficult to determine as there are a number of ways of proceeding.

It must be clearly understood that there is no correct hard and fast rule, no one system that can be said to be the proper system, as they all claim their own particular advantages. It was once the rule to grade wheat from the milling separator into two sizes, the large wheat going to the barley cylinders, and the small to the cockle cylinders, it being taken for granted that the barley and oats were all contained in the large wheat, and the cockle and other small seeds in the small wheat. The latest system is to send the wheat direct from the milling separator to a feed divider, which divides the stream into as many equal parts as there are barley cylinders, the whole of the wheat passing through the barley cylinders and each two barley cylinders feeding one cockle.

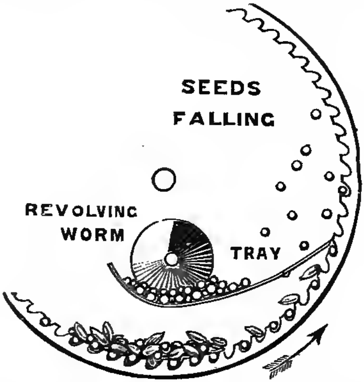
Indented Cylinders.—To understand the reason of this arrangement it is necessary to know how the cylinders work. Barley and cockle cylinders are known too well to millers to need much detailed description. They can be made any reasonable length, of from 4 ft. 1 in. long by 14 in. dia., to 10 ft. long by 32 in. dia., the most usual size being Nos. 3, 4 and 5. The outer case is usually made of zinc plates bent into a cylinder, the inner side having drilled or punched indents varying in size according to the separations they are required to make. The size of the indents has been standardised. No. 12 is the usual size indent used for separating wheat from barley and oats. Punched indents are usually preferred for this, as they allow one side of the indent to be flattened slightly, which provides a more secure resting-place for a grain of wheat than does a perfectly round hole. Inside the cylinder, which revolves on, not with the spindle, is a fixed tray, one edge of which projects close to the rising side of the cylinder. The grain running down the cylinder lodges in the indents and so is carried up to a point about equal to the figure 10 on a clock face. The oats and barley, being slightly longer than the wheat, tip out of the indents first and fall to the bottom of the cylinder again, while the wheat grains are carried a little higher, and when they fall are above the lip of the tray into which they drop. This tray, which is curved to form a worm-box, is fixed to the spindle, and, by turning the spindle slightly, the lip near the side of the cylinder can be raised or lowered, and thus a very wide range of adjustment is allowed to



CORCORAN COCKLE CYLINDER

suit the size of the grain being treated. In the lower curved part of the tray is a worm which carries the wheat deposited in it to the tail of the machine and delivers it out at the end, while the barley and oats gradually work down the inside of the cylinder and pass through the slots cut near the end.

The usual indents for the cockle cylinders are the No. 3 drilled: and these machines work in exactly the opposite way to the barley cylinders, the cockles and round seeds being carried high enough to drop into the tray, while the wheat slides down the inside of the cylinder and passes out through the slots. Both the barley and cockle cylinders are given a fall of about an inch in a foot. The wheat passes on to the next machine, while the barley and oats are sent to a re-barley cylinder, to recover any wheat that may be left in them. The cockle is sent to a re-cockler to recover any wheat that may have been lifted out with it. Sometimes the re-barley cylinder

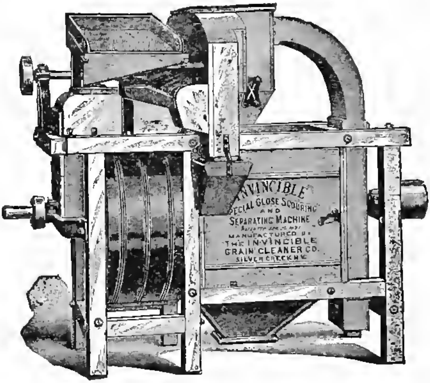


CROSS-SECTION OF COCKLE CYLINDER,
SHOWING HOW SEPARATION IS MADE

has indents one size larger than the original cylinder and the re-cockler one size smaller, though this is not absolutely necessary as the adjustment of the internal trays gives a wider range of separation than two sizes of indents.

It will be seen from the above that the indent cylinders have to lift every grain of wheat out of the barley and oats, and, theoretically at least, each indent only holds one grain at a time, and, as the barley cylinders have to lift out about 99 per cent. of the feed, more surface is required than for the cocklers, which only have to lift out 1 per cent. to 2 per cent. of the feed, while the indents being smaller there are about double the number of them to the square foot of surface, hence the reason for having two barley cylinders to one cockle cylinder.

Wheat Scourer.—The wheat next goes to the scourer. This consists of a perforated iron cylinder, through which runs a shaft carrying a number of beaters which revolve at a high rate of speed, scouring the wheat against the inside of the cylinder. The cylinder has long hole perforations all over it, and the impurities scoured off pass away through these slots which are too narrow to



INVINCIBLE WHEAT SCOURER

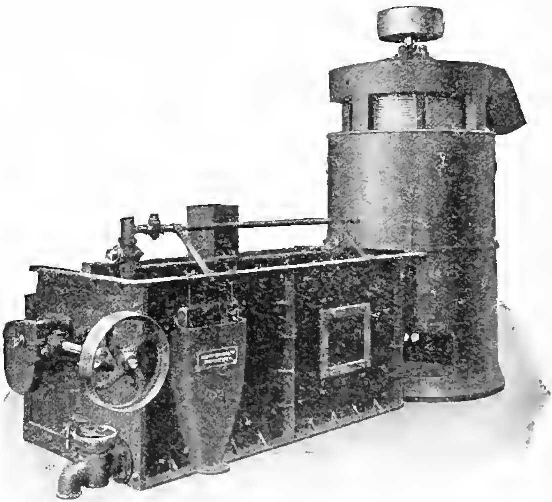
let the wheat through. Sometimes the inside of the cylinder is coated with emery to make the scouring more severe. The machine is provided with a powerful fan which aspirates the grain, and removes dust as the wheat enters the scouring chamber, all the time it is being scoured, and again as it leaves the machine. The scourer removes adhering dirt, scours off smut and beard, and more or less of the first bran coat. This is all exhausted away, and the wheat has a polished, smooth look.

Washer and Stoner.—The wheat next passes into the washer, which removes adhering dirt, dissolves clay-balls, separates stones, etc., and the wheat takes up a certain amount of water, partly depending upon the sort of wheat, and partly upon the time it is immersed in the water. Indian wheats are hard and flinty, and need a considerable amount of soaking. Indeed, when washing these wheats by themselves, it is not unusual to steam them first by running them along a 12 ft. worm, with a lid on, into which live steam is turned. Many millers wash their wheats in hot water, very often using condenser water from the engine for this purpose; otherwise the water can be heated with a steam-pipe coil in a tank.

Indian wheats should in all cases be washed by themselves first, and then washed again in the mixture. Theoretically it would be better to wash each wheat separately. In actual practice it is found quite satisfactory to wash similar wheats together; or, if hard wheats are given a preliminary washing, they can be washed in the mixture again, and—given a good modern conditioner, or even a good drier—let lie together in a blending bin, they will give and take moisture till they are all practically of the same softness.

Before the Indians have their preliminary washing they may be passed along the steaming worm, and this steaming will enable the water in the washer to penetrate the berry better than if the wheat is washed in its original harsh state. Good results can also be got by washing these wheats in warm water; but then they require passing through a drier with plenty of cold air to thoroughly cool them before going to the bin. They need washing twice to bring them to an even mellowness with most of the other wheats that are washed only once.

There are many forms of washers. The Mumford Patent, by Messrs. Henry Simon, Ltd., will serve for an example of this type of machine. It is in fact three machines in one, being a washer, stoner, and whizzer. The washer consists of a tank of water along which, partly submerged, runs a worm conveyor. Into this the wheat is fed, and wormed along through the water to the whizzer at the other end. Under the wheat



MUMFORD PATENT WHEAT WASHER AND WHIZZER

worm is a smaller worm conveying in the opposite direction. The wheat is carried forward by the upper and larger worm into the whizzer, while the stones being of greater specific gravity fall on to the small worm, and are carried back, and dropped into a receiving chamber. The action of the upper worm causes a flow of water which prevents the wheat being caught by the lower one, so that a complete separation of stones and wheat is made. The whizzer consists of a number of short blades fixed to a rapidly revolving drum, and set at an angle to carry the wheat upwards inside the perforated case in which they revolve. They also have a powerful centrifugal action which drives the water through the perforations in the casing, so that the wheat is discharged from the top of the whizzer fairly dry. The water in the washing tank can be kept at any desired depth. The dirty water running away continually is replaced by streams of clean water falling into the wash ng worm. The worm box is perforated so that the water passing through into the tank carries the dirt with it.

Some washers are of a double type, having two tanks and two worms, so that very dirty wheats can receive a double washing.

A simple type of washer and stoner is the "Concentric." This is in the form of a hollow cone filled with water into which the wheat falls. An upward flow of water carries the wheat with it out of the appliance, but the stones being heavier fall through the rising water into the point of the cone whence they can be removed by means of a trap. The wheat and water pass into a whizzer.

Dirt removal is, of course, the primary object in washing wheat. The modern washer was introduced to wash wheats like Indians, and some Russians, which contained hard lumps of clay that could not be otherwise eliminated. A dry stoning system was used before the washer provided a better and simpler way of extracting them. Before the washer was introduced, a damping-worm was used to damp such brittle wheats as Californians. This was simply a worm a few feet long carrying the wheat, into which a tap ran a stream of water. The chief object of this was to toughen the bran, and prevent it from being so much cut up in grinding.

In addition to its other use, the washer is of great importance as the first step in wheat conditioning. It is necessary to remember that Britain imports wheats from all parts of the world. Some are mellow, some soft, whilst many are hard and flinty with a very brittle skin, and these last require tempering as well as washing. Indians and some Russians and American Durums require softening as well as cleaning, and the quantity of water to be added to them depends somewhat on the district for which the flours are intended. There are again wheats which though already soft require washing for washing's sake, such as Russians, Plates, Winters and smutty English ; in fact, practically all wheats are washed nowadays, and the soft ones are dried again.

Another advantage of the washer is that out-of-condition English wheats can be dried much better after washing than if not washed. There is a natural sweating which forms a sort of gum on out-of-condition grain, and if this is removed wheat can be dried much more satisfactorily. All sorts of primitive forms of washing were tried, and dropped, before the modern washer was introduced.

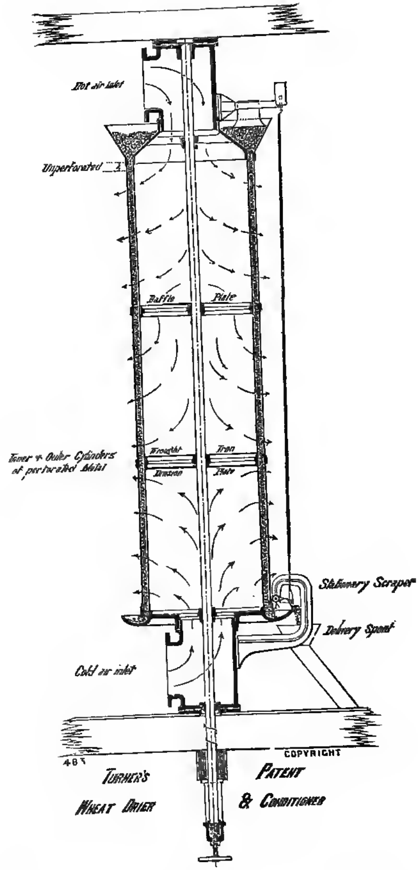
Conditioning Wheat.—It is now well understood that water is even more beneficial to the endosperm than to the bran, and mellowing the grain is of much more importance than toughening the outer covering. Certain hard wheats, when mellowed by proper conditioning, are stronger and yield better flour than if ground dry; and, when the miller has added 3 or 4 per cent. of water to the grain before grinding, the flour will make more bread per sack from the resultant flour than from the dry flour.

The chief aim, however, in conditioning wheats is to bring the whole of the mixture to the same degree of hardness or softness. To accomplish this it is sometimes necessary to wash some of the hardest wheats twice; wash without whizzing them the first time, and send them to a conditioning bin. These conditioning bins are a very important part of the process. It is only possible to wet the outside of the bran, and, as it is required to have the moisture distributed evenly right through the berry, the wheat must lie in a bin for the water to soak through into the inside of the berry.

The preliminary washing can be regulated to suit the harshness of any particular wheat. Indian wheats, which often have an earthy smell owing to the soil they contain, are washed and let stand till a slight fermentation is set up, which destroys the smell. In some mills all sorts of wheat are washed separately. In others, certain hard wheats are washed first, and then run into the mixture, and all washed together again. The extra cost of washing these wheats twice is justified by the fact that they are much cheaper as a rule. When the mixture is made up it should lie together to temper for twelve to twenty-four hours, *i.e.*, for the hard wheats to absorb some of the moisture from the softer ones.

When soft wheats are washed it is often necessary to dry them more than can be done by the whizzer. A wheat-drier is then necessary. It consists of a long upright chamber or chambers down which the wheat passes in a thin stream between perforated surfaces, passing over slight obstructions which continually break the stream, thus preventing the same grains from always being in the middle. Hot air is blown through the streams of wheat for about two-thirds of the length of its travel to carry off the moisture.

The wheat is then cooled by blasts of cold air during



TURNER'S REVOLVING WHEAT DRIER AND CONDITIONER the last third of its journey. The rate of travel of the grain can be regulated so that it remains in the apparatus a longer or shorter time according to how much drying it requires. The inlet and outlet are connected in such a manner that the wet wheat automatically enters as fast as the dry escapes, so that the chambers are always filled.

The drier made by Messrs. E. R. & F. Turner, of Ipswich, consists of two vertical cylinders of perforated metal, one within the other, the wheat passing between the two. The whole revolves; the dry wheat being discharged, by means of a stationary scraper, into the delivery spout at the bottom. The feed-hopper at the top, being connected to the scraper, regulates the discharge to the supply so that the machine is always full, otherwise the air would all rush through the vacant space instead of through the layer of wheat. Two fans are necessary on wheat driers, one for hot air, and one for cold. The warm air is heated by drawing it through a nest of steam-heated pipes.

The greatest difficulties in conditioning wheat are owing to atmospheric changes, inasmuch as the dampness or dryness of the air used affects the process. Wheat requires large quantities of air to carry off the moisture, and damp air naturally does not carry off as much moisture as drier air, and especially is this so in the cold section as the warm wheat might absorb moisture from the air used to cool it, so that considerable care and judgment are required.

The undoubted improvement which is seen in bread made from the flours of well conditioned wheats may safely be ascribed to equal diffusion of moisture in the wheat, and more even granulation of the flour owing to the fact that less pressure is required on both break and reduction rolls.

Another type of drier and conditioner is effective in that it uses very little air, so that it marks some change in the process. It was originally intended to use no air, but this was found to be impossible. The apparatus now to be described consists of three sections. The first section is for heating the wheat, which is done by passing it over a series of pipes heated with hot water, with the temperature of the water under the control of the operative. The section is filled up with exhaust ducts which serve to break up the travel of the wheat, and in heavily conditioned samples exhaust can be applied to draw off any desired amount of moisture, 3 to 3½ per cent. of moisture has been drawn off, this depending on the amount of air and heat used. The usual practice is to raise the temperature of the wheat to from 110 to 125°F., depending on the nature of the trade and of the wheat being treated.

The next section is used for cooling and aspirating the grain, also for drying when necessary. This is cut off from the top section by grids, thus enabling the top section to be filled with the wheat being heated. If it were not for this grid or slide, the wheat would pass through the heating section too quickly to be warmed.

The third section is entirely for cooling, and consists of cold-water pipes which cool the wheat as it passes over them. Wheat is an excellent non-conductor of heat, and it is necessary in this class of machine that provision be made to break up the vertical stream of wheat so that each grain can be heated and cooled equally. By extending the second, or aspirating section, wheat can, in certain circumstances, be cooled without using the third section. In the case of English or other soft varieties of wheat the results obtained by this method are almost as good as when the wheat is passed through the complete machine, as more air can be used.

But with the harder varieties of wheat it is desirable to use the minimum quantity of air, otherwise the bran will be too brittle. With a machine of this pattern having a capacity of twenty sacks per hour and an area of 3 ft. × 2 ft. 9 in., it will readily be seen that, were it not for some special devices, the tendency of the wheat would be to run faster down the centre than at the sides; but this difficulty has been overcome, and the grain is quite uniform in condition from whichever part of the machine it is taken. The whole machine is full of wheat, guided by channels of various designs. The gate at the bottom is actuated by the hopper at the top. The gate is set for a continuous flow, but, if feed accumulates in the hopper at the top, the weight in the hopper opens the gate at the bottom, and allows the excess to pass away. The gate controlled by the hopper is as sensitive as the feed of a roller mill.

Water is used at a temperature of 160 to 212°F., the heat being maintained by live steam, a valve allowing excess steam condensed to escape. The sides are insulated so that all heat is usefully absorbed by the wheat, and not blown into the room, with the result that the screen room is as clean as the purifier room.

The heat is only supplied through the water pipes, and the pipes are so spaced that the column of wheat is never more than 1½ in. thick. In it are placed air ducts and other devices in such a way that the column of grain is continually broken up.

Tempering Bins.—It is the practice of some millers to wash their wheats before they go to the cylinders and before scouring them. The advantages claimed for this method are—first, that the barley and oats are washed and freed from lumps of dirt and stones, and are therefore in a better state for use as provender; second, a wheat scourer is a very severe machine and apt to break some of the grains of brittle wheat, the broken grains being lost as far as flour-making is concerned. When washed before scouring the grain is toughened and therefore not so likely to break in scouring.

Whether it is scoured before washing or not, as soon as it comes from the washing and drying section of the plant, the wheat is sent into the tempering bins to allow the moisture taken up in washing to permeate each berry, which usually takes from about twelve to eighteen hours. There must be a sufficient number of bins to hold enough of the washed wheats to supply the mill for a certain period, usually twenty-four hours; as it is not usual to run the wheat-preparing department at night.

The wheat is drawn from the tempering bins by means of measuring devices, usually called wheat-mixers. One of these fixed under each bin, in the same way as those under the silo-bins, enables any desired quantity to be drawn from each bin to make up the mixture in the proportions required for the mill. If the wheats in the mixture have not been previously scoured, the mixture goes to the scourer and then to a brush machine. If it *has* been scoured it may be scoured a second time, but generally it goes at once to the brush machine.

Wheat Brush.—The wheat brush is constructed on almost the same lines as the wheat scourer, with the exception that inside the perforated cylinder, instead of beaters, a revolving, cylindrical brush is mounted on the shaft and brushes the wheat, giving it a final polish before it goes to the clean wheat bins in the mill proper. The wheat is aspirated as it enters the machine, all the time it is being brushed, and again as it leaves the machine. The combined action of the brushing and aspirating thoroughly removes the remaining dust adhering to the grain. The clean wheat bins should each be large enough to contain twelve hours' supply of grain, so that, if each sort of wheat in the mixture does not contain exactly the same amount of moisture, there may be time for some of the drier berries to absorb some of the moisture of the damper ones. About 15 per cent. of moisture is the amount in the wheat when it goes on to the first break rolls.

There is usually another wheat brush, or a wheat aspirator, in the mill immediately before the first rolls, to ensure that no dust passes to the breaks with the wheat, as such dust would seriously discolour the break flour.

A magnetic separator is placed before each scouring machine and before the first break rolls to extract any iron or steel, such as nails, bits of wire, etc., which might injure those machines.

CHAPTER VI

THE BREAK SYSTEM

THE modern system of flour-milling is summed up in the term "Gradual reduction." Every grinding machine reduces the grain a little, and separations are made between the reductions, partly-ground stock going on to be further reduced, while finished products are sacked off, ready for market. Grind, sift; grind, sift, is the order of the process.

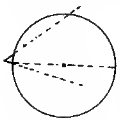
For convenience of nomenclature the grindings for extracting the endosperm, or floury parts, from the bran are called breaks and the remainder reductions. The break rolls open out the berry, and loosen its contents in the shape of break flour, dunst, middlings and semolina, commonly called chop. This chop contains a certain percentage of bran, broken up in extracting the endosperm from the bran, or skin of the berry. It may be well to point out that dunst, middlings, and semolina are not distinctive materials, but simply names given to broken pieces of the endosperm of certain well-understood sizes. The germ is a distinct body, differing in composition from the other parts of the grain. It is detached, generally whole, in the break process, and is of about the same size as the semolina, from which it is separated later on in the milling process. The great objects to be achieved in the break process are, first, to make as little actual flour as possible and as much granular stock—semolina and middlings—as is possible; second, to free the bran from the endosperm, and send it to the bran sack.

The clean wheat, coming on to the first rollers, is broken open and a certain amount of endosperm freed. This latter is sifted out, and the broken wheat passes on to the second break rollers. This process is repeated till only the bran is left, and, being dusted through a bran-duster, is sent to the bran sack. The number of breaks used once varied from two to as many as eight, but four have come to be recognised, generally, as the most satisfactory number necessary to give clean bran, and the largest percentage of semolina and middlings, though two or three only are often used in small mills.

When the roller system was first introduced, there was an idea that the crease of the wheat contained dirt of some sort, and endeavours were made to split the berry down the crease on the first break. For this purpose many kinds of machines were introduced, and many special groovings for the first break rolls were tried. As a matter of fact, the best that could be done was to split one grain in ten through the crease, the other nine being broken across, or having bits chipped off in various ways. Generally about half of 1 per cent. of dirty-looking flour was extracted at the expense of very considerable trouble and machinery. It took millers and milling engineers quite a number of years to discover that it was they themselves and not nature who made the dirty flour that they called crease-dirt.

Take a handful of flour, and a handful of clean wheat, mix them well together and sift. The result is a dirty-looking flour, for the wheat, or the bran of the wheat, will stain white flour, and that was what was happening to the first break. The lesson has been of great value to the trade, inasmuch as millers discovered the power of bran to discolour flour ; and machines have since been introduced to extract the break flour, at every break, as soon as it is made and before it is churned round with the broken wheat and so discoloured. The first break is now a real grnider, and frees a large percentage of the endosperm.

The break rolls are grooved, or fluted, from end to end with flutes the shape of a saw-tooth. The grooves are not cut in line with the axis of the rolls but slightly spiral, so that the grooves do not interlock with the corresponding grooves on the other roll of the pair, and further, so that they give a shearing action, somewhat after the manner of the blades of a pair of scissors. The amount of the spiral of the flutes has a great influence on the work done by the rolls, and, as the result of extensive tests, are now cut at an angle of 15 degrees to the axis of the roll. The fluting—more correctly speaking, the saw-tooth edges of the flutes—are set at an angle of 15 degrees to a line forming the diameter of the roll.



SHAPE OF FLUTE

All these rules have exceptions. Some firms use special fluting for the first break, while using the ordinary saw-tooth on the other three. Again, at times, the forward edges of the teeth are in a direct line with the diameter of the roll, giving a sharper cutting action. The following tables give the number of flutes per inch, and the speed of the rolls.

	Fast Roll.	*Slow Roll.*	*Flutes.*
1st Break	400 revols. per min.	160 revols. per min.	10 per in.
2nd ,,	400 ,, ,,	160 ,, ,,	14 ,,
3rd ,,	400 ,, ,,	160 ,, ,,	18 ,,
4th ,,	480 ,, ,,	160 ,, ,,	26 ,,

The difference in the speed of the two rolls gives the necessary grinding action, and is called the differential. Thus the first three breaks have a differential of 2½ to 1. The difference is obtained by means of gears, running in oil tight cases. Other means have been tried, such as driving each roll with a separate belt, but in this case there is always the danger of one belt slipping and the differential being lost. The flutes on the slow roll travel backwards, thus presenting their cutting edge to the cutting edge of the flutes of the fast roll, which face the direction of travel. The superior speed of the fast roll seeks to carry the flake through at its own velocity, but the sharp edges of the flutes of the slow roll resists this, so that a grinding, or shearing, action takes place, which detaches the flour particles from the bran.

The depth of the flutes form a recess into which the semolina falls, and thus escapes, without being reduced to flour. The depth of the flutes, therefore, decides to a great extent, the size of the semolina. For that reason the flutes are larger on the first break, and here the largest semolina is produced. Gradually, as the wheat is broken down and smaller pieces have to be dealt with, smaller, and therefore shallower flutes are used, those on the last break having only to scrape, or shear, the last particles of the endosperm off the bran.

In the early days of roller-milling very heavy feeds were rushed through the rolls, but it is now understood that, to obtain the best results, ample roll surface must be allowed. The standard diameter for rolls is 10 in., though other sizes are used. The length of the break rolls is anything up to 60 in. A pair of 60 in. rolls have a contact of 60 in, and the length of contact is always reckoned in estimating the capacity of these machines.

Technically this contact is spoken of as the roller surface, really the *length* of roller surface. The break system should have, at least, 40 in. of roller surface, per sack of flour per hour, manufactured. Often as much as 44 in. or 45 in. is allowed. This is divided about as follows: First break, 10 in.; second break 14 in.; third break, 12 in., and the fourth break, 8 in. When the whole wheat goes to the first break there are comparatively few pieces, but when they are broken up on the first break they cover far more surface than the original wheat, thus more roll surface is allowed on the second break, the object being to pass the particles through the rolls in a thin even stream, or layer, and not in a layer of pieces two or three deep. So much of the wheat has been extracted by the time the residue reaches the third break that less surface is required, and on the fourth, as only the bran is left with a little endosperm attached, still less surface is required.

The following table gives the average extraction of stock on each break.

	Percentage.		*Percentage.*	
1st break	20%	of stock extracted	20%	extracted from wheat.
2nd ,,	50%	,, ,,	40%	,, ,, ,,
3rd ,,	40%	,, ,,	16%	,, ,, ,,
4th ,,	12%	,, ,,	3%	,, ,, ,,

The first column of percentages refers to the quantity of stock extracted from the actual feed going to the roll; the last to the quantity extracted from the original wheat. If to this last be added the 21 per cent. of finished bran and waste, we have the 100 per cent. = the original wheat. These percentages of extraction, or in flour mill language "release," are often departed from, some systems releasing more on the first break, while others may leave more for the third break to do. The matter, somewhat, depends on the sort of wheat being ground, and its condition.

The usual—the almost universal—pattern of mill is the four-roller mill; *i.e.*, one frame containing two pairs of rolls. These are made of three types—

ROBINSON FOUR-ROLLER MILL

The *horizontal*, having all four rolls in a horizontal plane.

The *vertical*, having one roll of a pair immediately above the other.

The *diagonal*, having the rolls at an angle of 45 degrees to each other, or half-way between the vertical and horizontal.

The horizontal rolls take up a considerable amount of floor space, and are not too easy to adjust.

The vertical occupy the least floor-space, but it is not very easy to deliver the feed into the "nip" of the rolls, or to examine them when at work.

The diagonal pattern has none of the disadvantages of the other types, while possessing all their good points, in addition to a number of its own.

The feed hopper can be brought low down between the upper rolls, and the feed rolls set to deliver the feed right into the "nip" of the grinding rolls. The ground material can be examined readily, and the rolls, owing to their relative positions to each other, admit of easy and very accurate adjustment. The construction of the frame and hopper allows of the use of appliances to extract the break flour immediately it is made.

A modern roller mill is built in a strong, rigid iron frame, that prevents vibration, and carries the bearings and adjustments without strain. The bearings are long and self-oiling. The rollers themselves are made of chilled cast iron, and mounted on steel spindles, which are forced in by hydraulic pressure, and the rolls are turned up on their own spindles.

The top roll of the pair is the fast one, and is driven by belting which must be of ample width and strength. The lower roll is the slow roll, and is driven, or rather, its speed is determined, by a pair of differential gear wheels connecting its spindle with that of the fast roll, at the other end from the driving pulley. The slow roll is the adjustable roll, being brought up to the fast roll by means of levers and hand wheels.

The rolls of a pair must be kept parallel, or they will not grind evenly their whole length, and a means of adjustment is often provided for this purpose.

As modern milling is a continuous process, and the material flows automatically from one machine to another, it is necessary, while having an appliance that will spread the feed evenly the whole length of the grinding rolls, to have it, at the same time, self-acting so that it will take and pass all feed that comes to it. For this purpose a hopper is provided the same length as the rolls. The front of the hopper, or feed gate, is hinged at the top and kept closed with a spring. As the hopper fills with stock, the weight of its contents tends to push the gate open. The spring is adjusted so that it keeps the feed gate closed till the stock has spread the extreme length of the hopper; when it opens sufficiently to allow stock to escape, and, if the quantity of stock coming increases, its weight opens the gate sufficiently to let it pass through. The bottom edge of the gate rests against a revolving feed roll of small diameter, which assists the feed to flow out under the edge of the gate in an even stream. A second feed roll, just in front of, and a little lower than, the first, helps to spread the stock more evenly, and in a thinner stream, as it runs considerably faster than the first feed roll, and delivers the material to be ground into the nip of the grinding rolls at, approximately, the same speed as that at which they are revolving. The feed gate can, if required, be set in a fixed position to allow an unchanging quantity to pass. This is generally done when several machines are grinding the same stock, one feed gate only of the group being left to work automatically.

An adjustment at each end of the slow roller allows the rollerman to set the rolls to grind evenly at each end—and so along their whole length—and, to adjust the degree of fineness required, by bringing the bottom roll up as near to the top roll as is necessary for the particular stock it is working on.

When stopping the machines, one lever will throw both ends of a pair of rollers apart, and at the same time stop the feed. When starting it again, replacing the lever in its original position starts the feed, and sets the rollers grinding to the same degree of fineness as before.

An automatic flour mill is, in practice, one huge machine, of which each individual appliance is a unit, and every unit must do its proper share of work, and the satisfactory results given by each unit depend largely on those preceding it having done their share. For instance, if the fourth break were not properly cleaning the bran, it does not follow, of necessity, that the fault is with it. Either of the three previous breaks may not be doing its full share, thus leaving more work for the fourth than it should have to do. On the other hand, if the first three breaks, or any of them, were doing too much, there would not be sufficient left for the last to do, and it would be cutting up the bran, instead of cleaning it.

Grinding is the miller's art, and no amount of dressing machinery, or purification will annul the rollerman's bad work, or the bad work of rolls that may be out of truth, or working with dull flutes, owing to long wear. It is the rollerman's place to grind the stock, and it is his fault, as a rule, if it is badly done. If the condition of the rolls is to blame, it is still his fault if he has not discovered the cause of the trouble, and reported to head-quarters. Rolls not overloaded should run for from one to two years, but a great deal depends on their handling, and the condition of the wheat used. If the wheat stoner is not extracting all the stones these will soon spoil the fluting, and cause other troubles. Newly-fluted rolls are generally too sharp, and require several weeks' work before they give the best results. If, however, the fluting is badly worn, the rolls begin to crush the wheat instead of grinding it, and more break flour and less semolina is made. The depth of the fluting forms a refuge for the semolina while passing the point of contact, and, if the fluting has worn shallow, then the semolina is crushed, more of it is made into break flour, and what escapes is small, of a bad shape and difficult to purify, and there is a lowering of both the quantity and quality of patent flour. The desideratum is to make the largest possible percentage of semolina and middlings, and these are produced by the first and second break rolls which are coarsely fluted. The third and fourth break flutes are too fine to make large semolina.

Scalping.—Scalping is the technical term applied to the sifting process between each break for the separation of the chop—*i.e.*, the break flour, dunst, middlings and semolina—from the broken wheat and bran. This process has had more attention given to it of late years than, perhaps, any other operation in the mill proper, and many improvements have been introduced. Originally the scalping was generally done on hexagonal reels. The first break scalper is clothed No. 18 wire, and all the broken stock from the first break goes to it. The chop passes through the meshes of the wire cover, while the broken wheat tails over and goes to the second break. The second break scalper, clothed No. 20 wire.

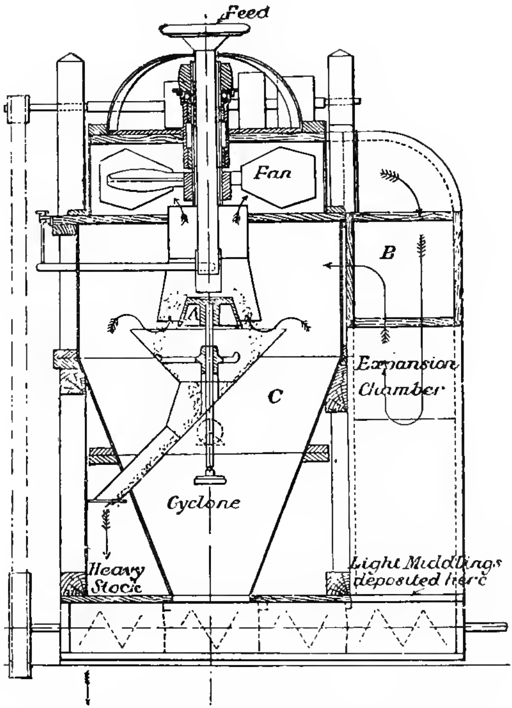
performs the same kind of operation, the overtails going to the third break. The third break scalper is clothed No. 24 or 26 wire, and the overtails go to the fourth break. The fourth break stock, usually, goes to a centrifugal dressing machine clothed with No. 36 wire, and the bran (overtails) from the centrifugal goes to the bran sack. Later it was discovered that a better separation and better stock was obtained by scalping through centrifugal dressing machines. Though the centrifugal flour dresser is described later, it might be mentioned here that it has a circular reel with fast-running blades inside it, which assists the stock to pass quickly through the meshes of the cover. For scalping purposes, a centrifugal fed at both ends and discharging the overtails at the centre of its length is used, the object being to give a short, quick travel, with sufficient force to make a clean separation. This system of scalping is still largely in vogue in spite of many new systems and machines.

Roll-Hopper Scalping.—Messrs. Henry Simon, Ltd., with a view to the prevention of contamination of the break flour, by churning it up with the broken wheat in an ordinary reel, or centrifugal scalper, adopted a plan of fixing sieves inside the break roll hoppers in such a manner that the stock coming from the "nip" of the rolls falls directly on a narrow sieve, running the full length of the rollers, and set at such an inclination that the stock slides down it. A strong exhaust draws a current of air through the sieve, carrying the break flour with it. The flour is trapped inside the hopper and is spouted away for further dressing, while the air passes away to the fan. The current of air, besides helping the flour through the meshes of the sieve, also keeps the rolls cool, and carries away any humidity that may arise in grinding.

The coarse stock, falling over the edge of the first sieve, falls upon a second sieve set at right angles to it. This is formed of wire, of a mesh suitable to the particular break it is scalping. Travelling down this sieve the broken wheat is freed from semolina, and other particles of endosperm, which are spouted away to be graded for the purifier. An exhaust, drawn through this lower sieve, carries off light branny flakes that have been detached from the wheat berry in the progress of grinding. The broken wheat, tailing over the second sieve, falls direct to the next break machine. A gentle knocking action, by means of a cam, keeps the meshes of the sieves clean. To save abrasion, and the making of attrition flour, the break rolls in this particular system, instead of being all placed on the first floor, are fixed, each on a separate floor, so that the stock can fall direct from one break to the next, without the intervention of elevators, or conveyors, as are required when all the roller mills are on one level.

Some other firms use various forms of sieves, inside the roll hopper, to extract the break flour as soon as it is made.

Pneumatic Scalping.—Messrs. Thos. Robinson & Son, of Rochdale, some years ago introduced a now much used machine called a Cyclo-Pneumatic separator, for extracting the break flour, without the use of sieves. A fan is mounted on a vertical hollow spindle. The whole of the break stock from a break is fed into this machine through the hollow spindle, and falls upon a rapidly revolving saucer which throws it off in an even circular spray over the mouth of a funnel. The fan, drawing a current of air up through the spray, carries off the break flour while the broken wheat, semolina, etc., falls into the funnel, and is spouted out of the machine. The break flour, passing through the fan, is blown into an expansion chamber at the side of the machine where, owing to baffle boards round which the air passes, most of it is deposited, and falls into a worm. The air,



ROBINSON'S CYCLO-PNEUMATIC SEPARATOR

and the lightest flour, pass back into the cyclonic hopper of the main part of the machine in which the air whirls round; the centrifugal action thus set up, throws the flour against the conical sides of the hopper, down which it slides into the worm below. The cleaned air passes over the edge of the funnel again, taking with it a fresh load of break flour from the spray of material, and thence to the fan. Thus a continual flow of the same air is kept up in the machine, which in its endless journey carries away break flour, deposits it, and returns to repeat the operation. No air enters or leaves the machine while it is at work. The break stock, less the break flour, after it leaves the cyclo-pneumatic, is passed over sifters which separate the semolina and middlings from the broken wheat, the former being graded and sent to the purifiers, and the latter to the next break rolls.

Messrs. Samuelson & Co., of Banbury, make a somewhat similar cyclonic separator, minus the side expansion chamber, the whole separation being made by the cyclonic action of the air in the machine.

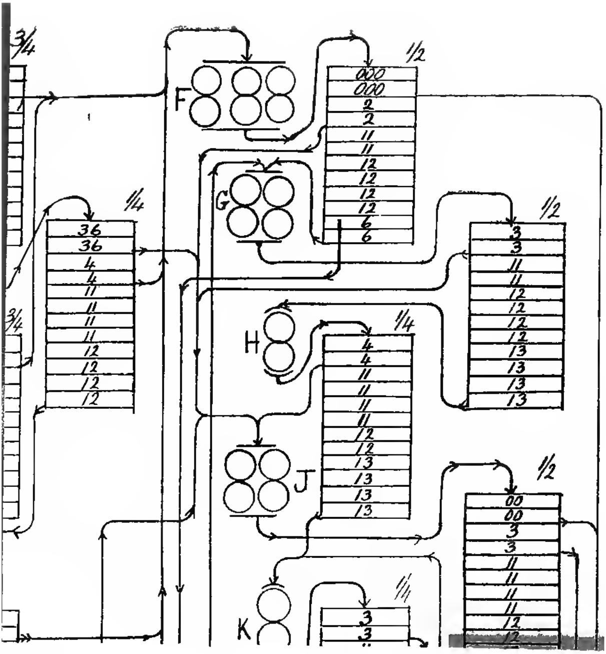
Plansifter Scalping.—Plansifter scalping is done on a machine so called, which, owing to the number of its super-imposed sieves, is able to scalp the break stock, dress out the break flour, and grade the semolina, etc., ready for the purifiers, all in one continuous process. This machine is described with the dressing machinery later in this book.

Enough sifting surface must be provided to ensure all the freed endosperm ("chop") being separated from the broken wheat, and a means of keeping the meshes of the scalper sieves clean is essential. If the mesh becomes blocked, or the sifting surface is insufficient, semolina will tail over to the next break with the broken wheat, overload the rolls and be reduced to break flour and contaminated. If the mesh of the scalper cover is too coarse, small broken wheat will pass through and escape the next break, while, if the surface is too great, an unnecessary amount of friction is set up, which will scour branny particles off the broken wheat, and they, joining the chop, will be difficult to separate again. The most modern types of scalpers are designed to perform their function in the gentlest possible manner, so that they shall not produce attrition flour from the semolina by severe action, nor scour "beeswing" off the bran, to contaminate the chop.

In large plants it is usual to devote a section of the scalper to grading the broken wheat, for the next break, into two sizes, the coarse going to one pair of rolls, and the fine to another. It is hardly necessary to say that this can only be done where there are two or more pairs of rolls on each break. The rolls grinding the fine broken wheat have finer flutes than those grinding the coarse. One rule, which is mostly exceptious, is that the fine flutes are the same as the coarse flutes on the next break. Thus the fine side of the second break would have eighteen flutes per inch, *i.e.*, the same number as the coarse side of the third break, while the fine side of the third break would have twenty-six flutes per inch the same as the fourth break.

Occasionally the wheat is graded into two sizes, when the first break is done on two pairs of rolls. In this case the large wheat is broken with ten to the inch flutes, and the fine with twelve to the inch. This, however, is seldom done now.

It might be thought from the foregoing that there are many systems of roller milling, but in reality this is not so, though there are a number of different ways of carrying out the system of gradual reduction which is still, and probably always will be, in a state of evolution. Put as briefly as possible, modern roller milling is a system of gradual reduction with an elimination of impurities at every stage of the process, impurities in the present case being the outer skin of the wheat berry,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and fibrous indigestible matter contained in it. One miller may run his rolls faster than another does, or he may have more or fewer flutes to the inch on any particular break roll. He may scalp on a vibrating sieve, or on a centrifugal reel. These are all means to an end. All aim

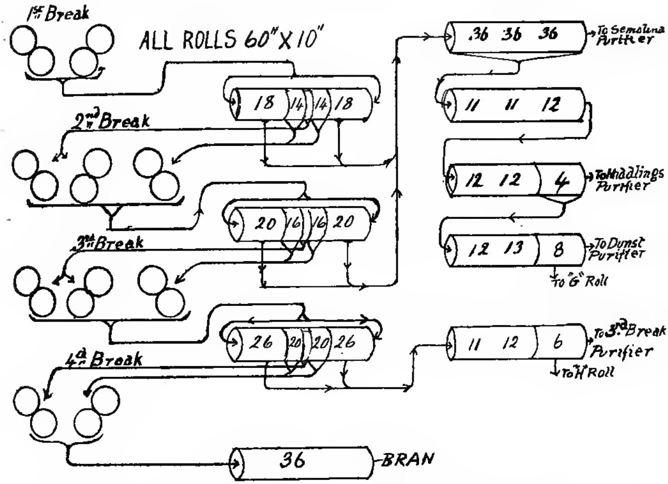


DIAGRAM OF CENTRIFUGAL-SCALPER BREAK SYSTEM

at the same goal, which is the extraction of the pure endosperm from the wheat in the largest possible pieces, so that they may purify it with air currents, lifting out the minute particles of fibrous matter, and then further grind it to pure flour by means of smooth rolls, which latter process is called technically the reduction system, as distinguished from the already described break system.

CHAPTER VII

MACHINES USED IN THE REDUCTION SYSTEM

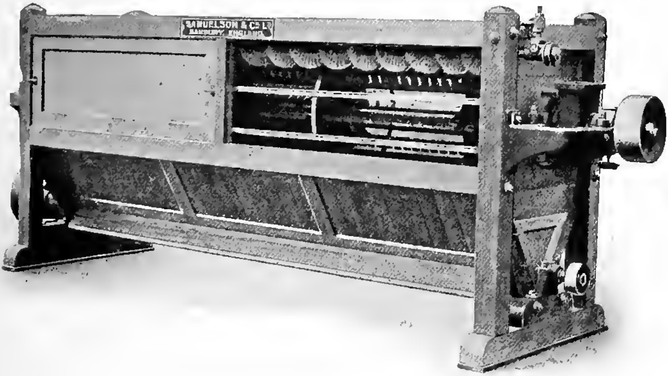
BEFORE describing the reduction and purifier systems, it will perhaps be as well to describe the various machines used.

Reduction Rolls.—Reduction roller mills are of exactly the same pattern as the break rolls, with the exception, that the actual rolls are seldom made more than 40 in. long. The rolls are generally smooth, but finely fluted rolls, having from eighty to 120 flutes to the inch, are used by some millers, and are fast gaining favour in the trade. Smooth rolls have simple scrapers fixed to the frame, and pressed gently against each roll to prevent flour from sticking to them, and being carried round and round, as considerable pressure is required in reducing middlings to flour. Fine fluted reduction rolls are fitted with a brush for the same purpose. The differential is very much less than in the case of the break rolls, being five to four, the fast roll running at about 250 revolutions per minute, and the slow one at 200. These are the speeds of 10 in. rolls. Smaller diameter rolls run faster, to give them about the same periphery speed.

When it is realised that the distance between smooth rollers, when grinding, is only the thickness of a particle of flour, it will at once be seen that they must be dead true from end to end, and perfectly parallel one to the other, to grind evenly their whole length.

The reductions—from two to fourteen it may be, according to the size of the plant—are lettered alphabetically. The first reduction " A, " and so on. This does not mean that all or any of the stock is possibly rolled fourteen times. It is grouped in grades according to the number of reductions, but every miller knows exactly what sort of stock goes to the " C " rolls, and what goes to the " F " rolls, and so on, in an averaged-sized plant.

Two reductions are called " scratch " reductions, the rolls of which are fluted 28 to 36 to the inch, and are



SAMUELSON CENTRIFUGAL FLOUR DRESSER

used to free semolina from bits of adhering bran, or to scrape endosperm off bran particles that have been broken small enough to pass through the mesh of the scalpers. They are always lettered " X " and " Y."

Any reduction may have two or more pairs of rolls, according to the capacity required. It is usual to allow 60 in. to 65 in. of smooth roll surface per sack of flour per hour, and 8 in. of scratch surface.

Centrifugal Dressing.—A centrifugal dressing-reel, usually called simply a centrifugal by millers, consists essentially of a slowly revolving reel inside of which are rapidly revolving beaters.

These machines, as a natural sequence to the width of the silk with which they are clothed, are always so many sheets, or half-sheets, of silk long, and a centrifugal reel 2 metres long (roughly 80 in.) is called a two-sheet centrifugal; one 100 in. long, being known as a two and a half-sheet centrifugal. They are built in various sizes from one sheet to three sheets in length, the latter being the largest in general use. The reel may be cylindrical, or polygon shape, the latter being the more modern. The beaters are thin blades, usually five to eight, of mild steel, the length of the reel, and carried on arms attached to a central shaft, which shaft passes through the ends of the reel. The beaters are notched on the outer edge, and, by twisting, more or less, the fingers thus formed, the travel of the stock along the inside of the reel can be accelerated, or retarded. A reel 30 in. diameter runs at twenty-five revolutions a minute, while the internal beaters, travelling in the same direction, run at 200. Centrifugal reels are constructed of various diameters. The machine is enclosed in a dust-tight, hoppered, wood case, with a worm conveyor running in the bottom of the hoppering to collect the "throughs," and deliver at any required point in its length.

Silk Bolting Cloth.—The silk used for sifting, or dressing stock in a flour mill is specially spun and woven for the purpose, the various meshes are numbered more or less arbitrarily from 0000 to 25. It is made in four strengths, standard, X, XX, and XXX, the latter being the strongest and most generally used. The following table gives the numbers, and corresponding mesh, of the silks—

No. of silk.	Mesh or threads per lineal inch of Standard, X & XX.	Mesh or threads per lineal inch of XXX.	
0000	18		
000	23		
00	20		
0	38		
1	48		
2	54		
3	58		
4	62		
5	66		
6	74	70	
7	82	74	
8	86	82	
9	97	86	
10	109	97	
11	116	109	
12	125	116	
13	129	125	
14	139	129	
15	150	139	
16	157	150	
17	163		
18	166		
19	169		
20	173		
21	178		
25	200		

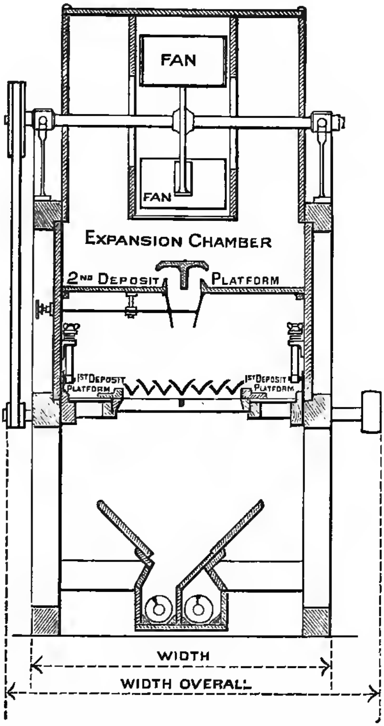
Nos. 9 and 10 are the coarsest numbers used for dressing finished flour, while No. 15 is the finest used, and this but seldom, Nos. 11, 12, 13 being the most general. The coarser numbers are used for grading partly-ground material. The extremely fine silks are made for sifting minerals and chemicals, entirely outside of flour milling. Treble X, it will be noticed, is tabled as having fewer meshes to the inch than the others. This is owing to the fact that, the threads being stouter, they have to be spaced a fraction wider apart to give the same sized mesh, or openings, as the others. All the holes are perfectly square.

It will be noticed, further, that No. 6 is the coarsest XXX number woven. If a coarser number is required then grit gauze is used. This is made of even stouter silk thread, and is woven in numbers, denoting the number of threads per lineal inch, from 14 to 72, increasing two threads to the inch at each step, *e.g.*, 14, 16, 18, 20, and so up to 72. These close numbers are necessary for grading semolina and middlings.

When speaking or writing of silk, the figures from 0000 to 15 are always understood to refer to the arbitrary numbers, while figures from 16 upwards refer to grit-gauze numbers. Woven-wire gauze is always numbered in the same way as grit-gauze, though the mesh varies from 2 to 260 meshes to the lineal inch.

Purifiers.—Though every process in a modern flour mill is one of purification, yet the term is technically applied to the work of separating branny particles from semolina, middlings and dunst, by means of air currents, and the machines used are called purifiers or sieve purifiers, the latter term being used to distinguish them from gravity purifiers, which were another type of machine used for the same purpose at an earlier period, but now practically obsolete.

The essential feature of the modern purifier is a long narrow reciprocating sieve clothed with silk, or grit-gauze, down which the stock travels in a thin even stream. A steady current of air, induced by an exhaust fan, passes up through the meshes of the silk, and through the granular stock, lifting out the impurities, technically called stive. An arrangement of tin, or wood, troughs, fixed above the sieve, forms a resting-place for the heaviest of the stive, and above that is an expansion chamber, through which the draught travels slowly, and in which the dust is deposited. The air passes on to the fan, more or less pure, and is blown out into the room, or into a filter dust collector. The sieve is



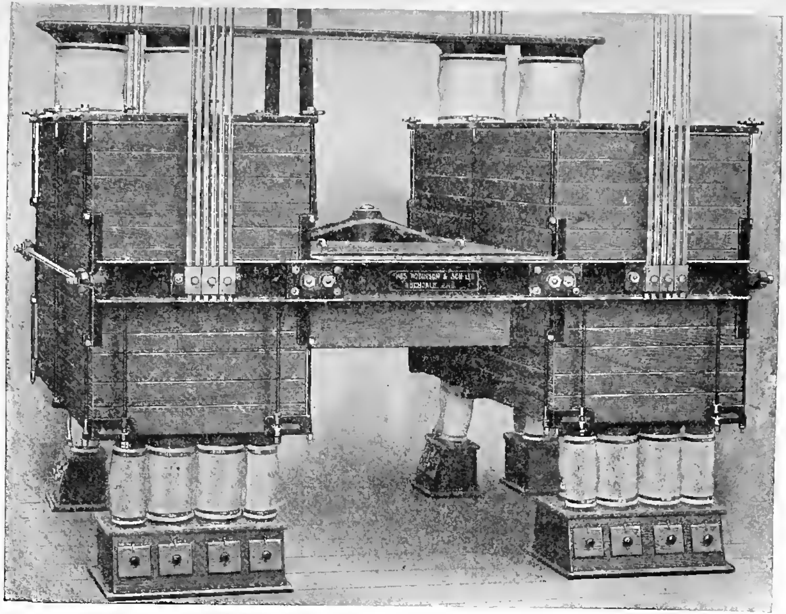
CROSS-SECTION OF ROBINSON'S SIEVE PURIFIER

clothed with four different meshes of silk, the finer numbers being at the head of the sieve. The chamber above the sieves is divided into four sections corresponding to the different silk meshes, and the strength of the air current passing through each section can be regulated by valves according to the size of the stock being purified. A travelling brush, under the sieve, keeps the meshes clean. Originally each purifier had a fan of its own, but now it is not uncommon for a number of purifiers to be connected by air trunks to a large fan which exhausts from them all.

Another sieve purifier is the Air-belt purifier, which differs from the above type inasmuch as the air is confined within the machine, and after passing through the fan travels back down below the sieve, and up through it again to the fan in an endless stream. The stive is trapped by special devices between the sieve and the fan, so that the air is practically pure when it passes from the fan to the sieve again. Purifiers generally have two collecting worms under the sieve, so that any portion of the stock may be "cut off" from the rest, and sent to a different reduction roll, or, if necessary, be repurified on another machine.

Plansifters.—The plansifter which was in a very crude form when introduced many years ago, and proved most unsatisfactory, both on account of its mechanical defects, and the difficulties encountered in trying to keep the meshes of the sieves clean, has, in quite recent years, been re-designed and is now able to challenge the supremacy of the centrifugal as a grader and flour dresser. As the name implies, the sieves are on a plane, or perfectly horizontal, the stock being impelled along the surface by the action of the machine, in conjunction with a number of slats projecting over the silk.

Vibration was the great trouble with the original plansifters, vibration so great that it shook the machines themselves to pieces, besides shaking the buildings they were installed in. The modern plansifters are so



ROBINSON'S FREE-SWINGING CRANKLESS PLANSIFTER designed and balanced that there is absolutely no vibration. They are not even rigidly attached to the building, being simply suspended by canes from the underside of the floor above them.

The machine consists of two chests of oblong sieves connected by an iron frame. Between the two chests are bearings in which a cranked spindle works. The crank revolves a balance weight as a counterpoise to the sieves. The throw of the crank is about 2 in., and the balance-weight keeps the spindle, which is only suspended from above, from rocking, while the sieves swing through a small circle with a perfectly smooth motion. Another make of these machines dispenses with the vertical spindle. The driving belt runs over two guide pulleys, attached to the frame of the sifter, direct to a pulley connected with the balance-weight. Plansifters are built with, up to, twelve sieves in each chest. These sieves are each usually divided into four sections, though sometimes, for small mills, they are divided each into six sections. The sections work in pairs, each pair having a tin tray under it to catch the throughs and deliver them to the head of one of the lower sieves, or to send them out of the machine, whichever may be required. Between each pair of sieves, and its collecting tray, is a triangular brush, with bristles on both sides. Through one angle of the brush is fixed a pin, which engages in two slots, one in the underside of the frame, between the pair of sieves, and the other up the centre of the tray. The set of the bristles in the brush, combined with the swing of the machine, causes it to travel continuously forward from the head of one sieve section along under the silk, round the tail end of the two sieves, along under the other silk section, round the head end, and so on continuously.

To understand the technical working of these machines it must be clearly understood that either the throughs or overtails of any sieve can be sent to any lower sieve, or spouted out of the machine altogether. Plansifters have been looked upon as having a very gentle action on the stock being treated. This may be true in some respects, but, as a matter of fact, they have a most severe sifting action. The argument against them, in England, was, that they would not dress the flour from soft native wheats. This, however, was only an idea, as is proved by the fact that these machines show to better advantage when working on the soft stocks from the last reductions than anywhere else in the system. What the relative advantages of plansifters and centrifugals are, has been, and still is, too debatable a matter to be dealt with here, each have their good points, and their adherents. One of the chief merits of the plansifter is its large capacity, as compared to the floor space occupied. Another is the small power required to drive it.

Detacher.—In grinding with smooth rolls, there is always a tendency to flake the stock, especially in the lower reductions where the material is becoming soft. When wheats contain a high percentage of moisture, and are tough, it is almost impossible to avoid flaking some of the stock and, naturally, flaked stock will not dress properly. To surmount the difficulty the detacher was introduced. It consists of short lengths of worm, or short propeller blades, in a cast iron chamber. The material is fed into the chamber and stirred round and forward by the propeller, and forced through a trap door, which is kept shut by a spring, till the force of the blades, pressing the stock against it, causes it to open enough to let it through. A kind of gentle rubbing action is introduced which disintegrates the flakes, and the stock is discharged in good condition to dress freely.

It is usual to fix a detacher after each set of smooth rollers and a by-pass spout is provided, so that the material can go direct to the dresser without passing through the detacher, if desired. Probably in dry bright weather it is not necessary on all, or even any, of the reductions, while in damp weather it will considerably assist the work of the dressers, and so maintain their capacity, and the quality of the flour, under varying conditions. The power required to drive these machines is very small.

CHAPTER VIII

THE REDUCTION SYSTEM

THE break system section of the mill, having eliminated the bran, leaves the chop to be further dealt with. Chop, as explained before, is the endosperm as broken from the bran by the break rolls, and separated from it by the scalpers. It consists, in flour mill phraseology, of germ, semolina, middlings, dunst, and break flour, mixed with which are bran snips, bran dust, cell walls of endosperm, and other fibrous matter.

Semolina is that part of the chop that will pass, indeed, has passed, through 18-mesh wire, but is too coarse to pass through 40-mesh grit gauze. It can be further divided into coarse and fine semolina.

Middlings pass through various meshes between 40 grit gauze and No. 7 silk. They may also be subdivided into coarse and fine.

Dunst is very fine middlings, dressing through any numbers between No. 7 silk and the actual flour silk.

Greys are small fibrous impurities in flour or dunst.

Grading and Dusting Chop.—Presuming a mill is worked entirely on the centrifugal system, the chop from the first and second break scalpers—and it may be from the third also, though this is often treated separately—is carried to a centrifugal, which sifts out the finer stock through No. 40 g.g., the overtails being semolina, which goes to the semolina purifiers. The throughs go to another centrifugal, which is clothed with flour silk for the first part of its length, and with No. 7 silk on the second section. The first section dresses out some of the break flour. The second section lets through dunst and remaining break flour, while the middlings are tailed over to the middlings purifiers. The flour from the first sheets go to the sack, while the throughs of the second section go to a third centrifugal clothed with about 10 and 12 silk. This machine thoroughly dusts the remaining break flour out of the dunst, which can then go to the proper purifier, the flour going to the sack.

It is most important that no flour should reach the purifiers. In the first place, it would be, more or less, carried away by the air currents with the stive, and reach the offal sack instead of the flour sack. In the second place, it would load up the purifiers and prevent that free passage of air that is necessary to carry off the impurities.

For these reasons, it is imperative that the chop dressing and grading machines should be well up to their work. They can be duplicated, or triplicated, to obtain any required capacity.

The third break chop is of much poorer quality than that from the first and second breaks, and, for this reason, is generally dusted and graded separately, only the very best of the middlings ultimately finding their way to the head of the mill. The fourth break chop is always treated by itself, as the middlings are very poor and specky, and only fit, even when purified most carefully, for reduction low down the system. The reason for the third and fourth break chop being so poor in quality is because all the best of the endosperm is extracted on the first and second breaks, leaving little for the last two breaks to do except clean the bran.

Purification.—The semolina may be graded into two or more sizes for purification, but often it is simply divided on to the two sieves of a double purifier. The advantage of this is that, if anything goes wrong with one sieve, the whole feed can be turned on to the other for a short time, without very much upsetting the flow of the mill.

The meshes of the purifier sieves must correspond to the meshes of the covers of the previous machines that the stock has come through, and tailed over. Semolina has come through 18-mesh wire on the scalpers, and tailed over No. 40 grit gauze on the first chop centrifugal, and consists of granuals in between those numbers. The four sections of the purifier sieve might, therefore, be clothed first sheet 38 g.g., and the last one 18 g.g. ; the two middle sheets being clothed with as nearly intermediate numbers as possible, say, 32 and 24. This would give the numbers 38–32—24–18. The feed, coming through the feed gate, falls on the head of the sieve, and, travelling over the 38-mesh, a little pure stock falls through that section. At the same time, the air current, passing up through the sieve and the stream of the feed, lifts impurities out, or prevents them passing through the sieve. On the next section, a slightly stronger draught is used, owing to the size of the stock being generally a little larger, and not so easily floated off. The same applies to the remaining sections. As the stock is sifted through, there is less to travel on down the sieve, and so stronger air currents are needed to prevent light, branny material falling through. Whence the need of the divisions inside the purifier. Light impurities are lifted out, and deposited in the trays and expansion chambers, while the heavier ones are floated over the tail for further treatment. Each purifier sieve is suspended by four adjustable hangers, one at, approximately, each corner of the sieve. The angle at which these hangers are set regulates the speed at which the stock flows down the sieve. They are also adjustable to lower or raise either side of the sieve, to enable the purifier-man to level the sieve.

If it is not level, stock will travel down to one side of the sieve, leaving the other side bare, and the air will rush through the bare patch, instead of through the stock to lift out the impurities. A crank shaft across the head end of the machine, gives a backwards and forwards motion to the sieve, at a speed of about 450 vibrations per minute. The tail sheet being the same mesh as the semolina had previously come through, would naturally let it through again, but the air current will float some of it, with light bran chips attached, over the end of the sieve. If the throughs close to the tail are not pure enough, they can be cut off into the lower worm, and sent to scratch. The feed hopper and feed roll of a purifier are almost the same pattern as that on a roller mill; their duty is to spread the feed into a stream the width of the sieve, but only one feed roll is used.

All the purifiers work exactly on the same system, and the stock according to grade then goes to the reduction rolls.

The purifier, although treating the unreduced granular material at the head of the mill, yet makes its influence felt all down the system. Certainly it improves the quality of the "C," or patent flour, by eliminating fibrous matter from the middlings, but, if that matter were not extracted at the head of the mill, it would cause serious trouble at the tail. It would pass through one set of reduction rolls after another, contaminating the flour from each in turn, and, being gradually reduced itself, would be practically impossible to separate from the last reduction flour. In addition to lowering the quality of flours, it would add to the work of the various rolls, and so overload them and prevent them from doing their correct work. Elimination of impurities at the earliest possible point in the system is one of the main features of gradual reduction. Grinding impurities, instead of getting rid of them, is a most costly process. It is, in fact, working hard to spoil good flour. In some mills, secondary middlings from the cut-off sheets, or overtails of certain dressing machines, are purified; but, as a general rule, only break or primary middlings are exposed to air currents, as when they have been through smooth rolls once they are not so granular, or in as good a shape for the purifier, as those direct from the breaks.

Reduction Rolls.—"A" and "B" rolls are at what is often called the "head" of the mill, and the whole aim, so far, has been to produce the greatest possible amount of feed for these rolls. They are only partly grinding rolls, their real duty being to flatten the germ and size down, or crack, the semolina to get it into the best possible shape for the "C" rolls. The "A" rolls reduce the semolina, and the "B" rolls the middlings, to a smaller size, and flatten out the germ, most of which is to be found in the semolina. When a number of pairs of rolls are used on "A" and "B" reductions, the stock may be graded to them according to size, and often those taking finer stock of their class are numbered "A2" and "B2." The reduced material from these rolls is dressed through dressers numbered or lettered the same as the reduction rolls. Thus, the stock from "A" roll is dressed through "A" centrifugal, or "A" plansifter, and so on all down the system.

The flour from "A" and "B" reductions is very white, but is mostly starch and not over strong, the gluten being chiefly contained in the granular material that is passed on to "C" rolls. "A" centrifugal, as also "B," has to make three separations, and, therefore, has what is technically called a tail sheet, or cut-off sheet. The two first sheets are 11 and 12 silk dressing out the flour, which goes at once to the sack. The throughs of the tail sheet, No. 4 silk, are pure, fine middlings going to " C " rolls, and, when ground and dressed, yield the best, or patent, flour.

The overtails of " A " centrifugal contain flattened out germ and branny particles that had adhered to some of the semolina. No middlings that will not pass through a No. 4 silk should be sent to the " C " rolls. No stock that has not been treated on the " A " or " B " reductions should go to " C." If any middlings tail over " A " centrifugal, they are sifted out of the overtails and sent to " B1 " roll, to be cracked down, and so to the " C " roll with " B " centrifugal tail sheet stock. The overtails of " A " and " B " centrifugals go to " F " rolls with other coarse stock of the same class gathered from various parts of the system. The overtails of the semolina and middlings purifiers, and also the cut-offs, are sent to the scratch rolls. The best of this stock consists of wheat chips, or pieces of bran with semolina and middlings attached, and this is sent to " X " rolls, which act in the same way as break rolls, detaching the bran particles from the adhering endosperm, making as little flour as possible in the process. By careful dressing and purification, a useful percentage of middlings can be obtained from this reduction, and sent to the head of the mill. The more branny stocks from purifier tails and " X " centrifugal go to " Y " rolls.

Fifty per cent. of the roll surface should be allowed to " A," " B," and " C " reductions, and 40 to 50 per cent. of the flour should be produced on these rolls.

" C " Rolls.—The " C " rolls are set to grind as close as possible without injuring the stock, or flaking it. The middlings have been prepared carefully, and consist, practically, of pure flour in a granular form, and the granules require reducing to yield the largest percentage of flour that it is possible to release at one rolling. Being pure, it does not require very fine dressing, and the "C" centrifugal can be clothed 10, 11, and 12 silk. There is a special reason for clothing a dressing machine finer at the tail than at the head. The full load of feed comes on to the head sheet, and the finest granules of flour pass through first and easiest. As the bulk in the cylinder decreases, the sifting action becomes more searching, and impurities might be forced through if finer silks were not employed where less work has to be done. By clothing finer towards the tail, the dressing is equalised, and the throughs freed from specks, all the length of the machine.

The overtails of "C" dresser pass to "D" reduction, where they are joined by, and ground with, other stocks, such as the best of the fourth break middlings, and dunst from the cut-off of the dunst purifier, which were not quite good enough to go to the "B" reduction. "D" centrifugal stock has some impurities which may well be eliminated, and for that purpose the machine has a tail sheet, the throughs of which go to "E," and the overtails are sent either to the offal sack or to one of the lower reductions, "F" or "J," which are grinding branny stock. The impure stocks from third and fourth breaks, from the cut-offs and tails of purifiers, are brought in on the lower reductions wherever it is most suitable, having regard to the stocks and the impurities in them. Each of the lower reduction centrifugals has a tail sheet, the throughs of which go to the next reduction, while the overtails are sharps, which go to the offal sacks. Thus, three separations are made after each reduction, the head sheets of the dressers yielding flour, the last sheets dunst for the next reduction. and tailing over impurities to the offal sack. If the germ is required as a separate product, it is sifted out from the tailings of " F " centrifugal by means of a small vibrating sieve. The germ is of such an oily nature that if left in the flour it soon becomes rancid and spoils the flour.

Offals.—In some districts it is necessary to have an offal grader, to which all offal is sent, and graded into various sorts to meet the market requirements. Bran is frequently sifted into two sizes, " small " and " broad," and rolled through smooth rolls to broaden it out and give it a smooth, silky feel. The need of any of these ways of treating offals depends on the custom of the districts where they have to be sold.

The Plansifter System.—The plansifter system of dressing differs in several details from the centrifugal system. Owing to the number of sieves in a nest, the chop dressing and grading machines, as separate items, are non-existent. The top sieves scalp the break stock, tailing over the broken wheat to the next break, and, if need be, grading it into two sizes. The next sieves tail over the semolina in one or two grades. The following five or six sieves dress out the break flour, while the last sieve, or sieves, separate the dunst from the middlings. It may be necessary to further grade the stock for the purifiers, in a very large plant, over a special grading plansifter, to distribute it more evenly to a number of purifiers. It may be taken that four to six stocks can be treated on one plansifter at the same time in small mills. In large plants, the whole plansifter can be used on one stock, or half or three-quarters of a machine, just as circumstances require. As flour dressers in the reduction system, they have the advantage that the top sieves eliminate the coarse offals first thing, so that they do not pass over the whole sifting surface of the machine, as they have to do in a centrifugal, before they can be tailed over.

In damp, foggy weather, it is very difficult to dress flour properly, as the meshes of the silk will not pass the flour so freely as in bright, dry weather. The only remedy in most cases is to reduce the feed, so that the mill, as a whole, has less work to do, and the dressers can cope with the work. So much does bad weather affect the dressing capacity that it may be necessary, at times, to reduce the feed 20 per cent., or even 25 per cent., to prevent flour passing with the dunst to the next reduction roll. It is not an uncommon thing for millers to clothe a number of their dressers with coarser silks in the winter months to minimise this trouble. With plansifters, it is possible to have one or two extra sieves—out of use in dry weather—over which the stock can be passed in damp weather. Another feature of this machine is that, owing to its sifting action, the light impurities have a tendency to work up on to the top of the stream of stock, and so there is less chance of them being forced through the meshes. At the same time, the stock that is required to pass through the sieve works down to it, and passes through more freely, the light stock not being next the silk to obstruct it. To this, in a measure, may be ascribed the large sifting capacity of these machines. The chief difficulty in connection with these sifters is in getting at any of the sieves to change the silk, or to mend holes in it. The sieves in a chest are all nested into each other and clamped together, so that, to get at one of the lower sieves, it is necessary to dismount all those above it, which, of course, takes some little time. However, there is so little wear on the silks in this type of machine that the trouble does not often occur, and in many cases it is possible to divert the stock and run on till the week-end, and repair or change the silk then. Only one section of a reel, or centrifugal, is sifting at a time, that is, the rising side of the reel—the descending side is nearly idle, as practically all the stock is on the rising side. In the case of the plansifter, the whole of the silk surface is covered with stock, and at work all the time.

The foregoing relates to the systems in medium-sized and large mills, say, those having a capacity of anything between four sacks of flour per hour and fifty sacks per hour.

Mills having a larger output than fifty or sixty sacks of flour per hour usually divide their machinery into two or more separate plants, though there are one or two mills in England having a capacity of 100 sacks per hour or over on a single plant. The objection to such excessively large plants is that, if anything important breaks down, the whole plant has to stop till repairs are effected, whereas, if there are two plants installed, each of half the total capacity required, only half the output is cut off if a breakdown occurs. Another objection is due to the insurance. Premiums increase from the base charge according to the size of the plant, so that the insurance charges are less on two fifty sack plants, in two buildings, than on one 100 sack plant, in one building.

Small Mills.—Though the system is the same, in principle, in roller mills of all sizes, yet in small mills it has to be shortened in many details. In the smallest plant, two breaks only are used, followed by two reductions. In this case, the first break rolls have to "come down" heavily on the wheat to free the endosperm, doing practically the work of the first and second breaks, leaving the second, or last, pair of break rolls to clean the bran. In the reduction section, the first pair of smooth rolls has to perform the duties usually done by "A," "B," and "C" rolls, while the second has to do the work of all the lower reductions. This they can do very successfully, if the roll surface is as long in proportion as in larger plants with more breaks and reductions.

Two pairs of 20 in. long break rolls, followed by two pairs of 30 in. smooth rolls, producing a sack of flour per hour, would have 40 in. of break surface and 60 in. of reduction surface per sack of flour per hour, which is about equal to that allotted in the largest mills.

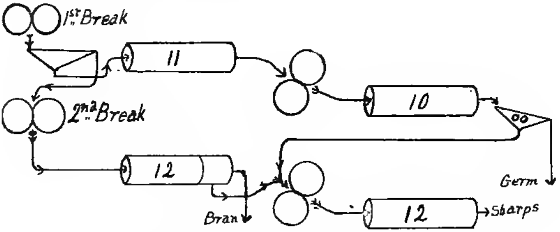


DIAGRAM OF VERY SMALL PLANT

In some small mills, having three or four breaks, one of the last breaks is made to do the scratch roll work as well as to finish the bran.

Other economies are made in the number of machines, etc., without materially altering the system.

There is one rule in flour milling that is never broken, and that is, no stock must ever go back to any machine a second time. All stock must travel forward down the system, whether the system be a long or a short one. There must be no "returns," as a miller would say.

The Customs Authorities, in recording the imports of breadstuffs, reckon 70 lb. of flour as 100 lb. of wheat: and this is about correct, as, in a general way, millers make 70 per cent. of flour from the wheat as received by them. Some wheats, naturally, will yield more flour than others, but 70 per cent. is a very good average. The flour, when made, is usually divided into two, three, or more grades, according to the market requirements of particular districts. The flour from "C" reduction is the best or "Patent" flour, and that from each of the other dressers varies in quality; the last reduction being the poorest, though that from the fourth break runs it very close. Of the other 30 per cent. of the wheat, about 14 per cent. is sharps and 16 per cent. bran.

CHAPTER IX

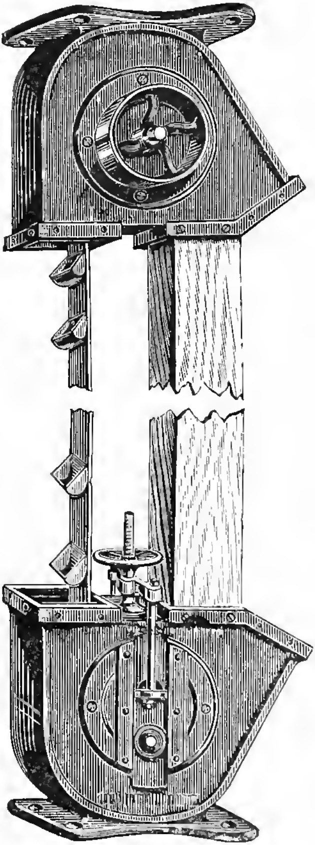
AUXILIARY APPLIANCES

THERE are many auxiliary appliances of great importance in a flour mill, such as elevators, conveyors, air trunks, exhaust fans, dust collectors, spouts, etc.

Elevators.—Elevators are required to carry any stock from a machine on a lower floor to one on a floor above. Usually, machines are so arranged that the stock, once carried to the top of a mill, passes through several machines on its journey downwards, so that most of the elevators run from the ground floor up into the apex of the roof. They are formed with a pulley at the top, and another at the bottom, of a width of face and a diameter suitable to the quantity of stock to be elevated. Round these pulleys runs an endless belt, usually of hemp or cotton webbing. To the webbing, at regular intervals, are attached buckets, or cans, of a proper shape, and the whole is enclosed in wooden trunking to prevent the escape of dust. The stock is spouted into the bottom part of the elevator, carried up by the travelling buckets, and delivered at the top, whence it is spouted to the desired machine. The buckets and webbing should travel at a rate of about 280 ft. per minute, as at this speed the buckets best discharge their load. Usually, when the buckets do not deliver properly, they are travelling too fast, though it may be that they are too slow.

Spouts.—The spouts conveying stock in a flour mill from one point to another by gravity must be of wood. If they are made of metal, moisture will condense in them and clog the flow of the material.

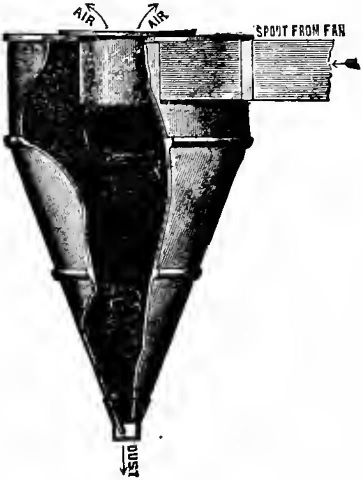
This applies to all machinery in a flour mill, and, for this reason, all the stationary machinery that stock comes in contact with is constructed of timber. The casing of reels and purifiers, and the collecting hoppers, are built of wood, and the insides of roller mill hoppers are lined with wood to reduce the condensation of moisture.



BELT AND BUCKET ELEVATOR

Most mill stock will run down spouts having a fall of 45 degrees, but flour, and especially fourth break flour, requires spouts with a steeper angle. Wherever there is a bend in a spout, or wherever the spout passes through a floor, there should be a hand-hole cut in it, and fitted with a lid, so that if it gets blocked up the operator can get his hand in and clear it without difficulty, and quickly. Blocks will occur even in the best arranged and constructed mills. A belt may come off, and a machine stop, and immediately the spout feeding the machine will fill up, and, if there were no hand holes, it would be impossible to clear it.

The spouts are usually $2\frac{1}{2}$ in. by 6 in. inside measurement, though the actual size depends on the stock they have to contend with. They are set so that the stock runs down on the 6 in. side. If the spout is diamond-shaped, the stock will not run so well, as running in the angle of the V causes more friction. At the same time, such spouts are unsightly. A perpendicular

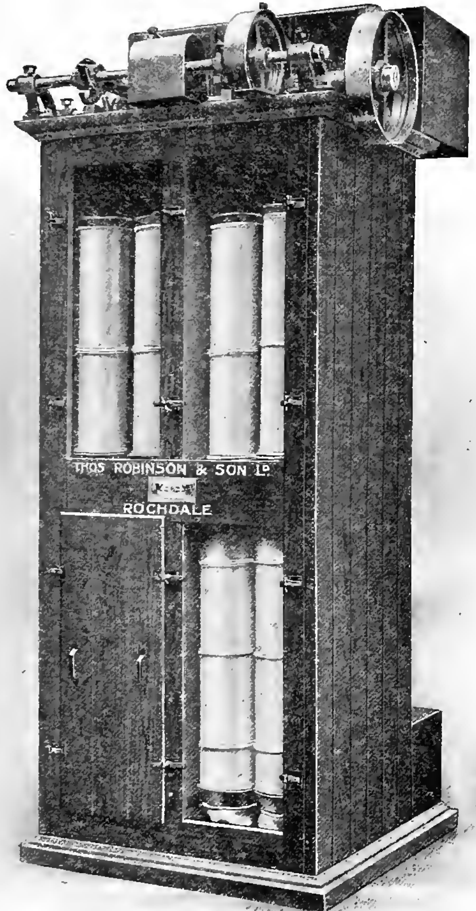


CYCLONE DUST COLLECTOR

spout is to be avoided, as stock falling direct, instead of sliding down, creates dust.

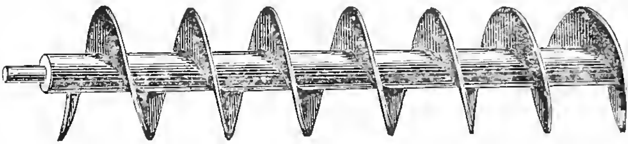
Dust Collectors.—It is usual and, indeed, necessary to exhaust the humid air from all machines in a flour mill, as well as the impurities from the purifiers, and dust and dirt from the wheat. It is, therefore, necessary to provide some sort of filtering apparatus, to separate the dust from the air used for these various purposes. Originally, the air was blown into rooms, called stive rooms, in which some of the dust settled and the air escaped, carrying more or less of the dust through a ventilator with it, so that at one time the roofs of most flour mills were covered with dust. A number of machines were introduced to retain all the dust, while allowing only pure air to escape. The first really successful appliance was the cyclone dust collector, which owed a good deal of its success to the approval it met with from the fire insurance societies, who would not allow the use of textile dust collectors, except on payment of prohibitive premiums. The cyclone is made of metal, the lower part being a hollow cone, and the upper part being a short cylinder. The air and dust are blown sideways into the cylindrical part, setting up a cyclonic action, the centrifugal force of which throws the dust to the sides of the cone, down which it gradually works to the point, whence it escapes and is sacked off. The air passes away through an opening in the centre of the lid of the cylindrical part. A short round spout is carried down from the opening in the lid at the top to the level of the upper part of the conical section, so that the whirling air has to travel down into the cone before it can escape. It is thus retained in the machine a sufficiently long time for the centrifugal force to separate the dust from it. No power is required, as the circular action of the air and the shape of the machine make the separation, which, though very good, is not quite perfect.

The insurance companies, after a time, realised this last fact, and, knowing only too well the fire risks attendant on floating dust, permitted the use of textile dust collectors. These consist of a number of canvas sleeves, or tubes, chemically treated to render them fire-proof. Open at one end, to admit the air and dust, they are closed at the other end, so that the air has to filter



ROBINSON'S SLEEVE FILTER DUST COLLECTOR

through the closely woven canvas material, which retains the dust. The sleeves are grouped in air-tight chambers to prevent outside air entering. Each group of sleeves, in turn, has the exhaust cut off for a minute or so, and while no air is entering that group is agitated sharply, and the caught dust is shaken from the insides of the sleeves and falls into a receptacle below. The sleeves in a section are shaken from five to ten times in succession, at intervals of about five minutes. During this time, the filtering process is not interrupted, as all the other sections are at work. The valve of the cleaned section re-opens, and the next closes while the sleeves in it are agitated. There may be six or more



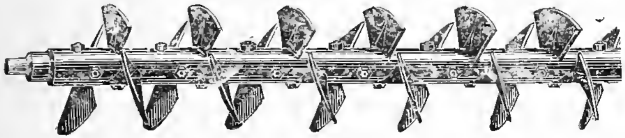
CONTINUOUS WORM CONVEYOR

sections to one machine, each containing any number of sleeves required to deal with the volume of air being filtered. There are two usual types of these machines, the suction and the pressure. In the suction type, the fan draws, or sucks, the air through the sleeves. In the pressure, the fan blows into the apparatus. This pattern does not really need the sleeves to be enclosed in chambers, as the pure filtered air may be allowed to escape into the room where the collector is situated.

Worm Conveyors.—One of the most indispensable appliances in a modern mill is the screw, or worm conveyor. It is simply an Archimedian screw with such large threads that they are called wings or flights

Two patterns are used, the continuous, and the broken blade, or paddle. The former is formed by stout sheet iron blades, forming the screw, twisted round an iron pipe. Short spindles are fixed in each of the ends to form journals, and to connect the various lengths of pipe. This pattern has a large carrying capacity, but has the disadvantage that the direction of the screw cannot be altered, for part of its length.

The broken bladed worm is formed of numbers of separate blade sections, or paddles, each having a shank, which fits into a hole drilled in the centre pipe, or spindle. A nut on the ends of the shank keeps it in position, and allows the blade to be set to make a section of



PADDLE OR BROKEN BLADED WORM

a right or a left-hand screw. Four paddles form one thread of the screw, or, in other words, one wing of the worm. By slackening the nuts, and inclining the paddles in the other direction, the worm, or any part of it, can, in a few minutes, be made to carry stock in the other direction. This is a great advantage, as it is often necessary to collect stock from each end of the worm, and bring it to a spout at some intermediate spot. The worm is encased in a trough, called the worm box, made of iron or wood, according to the material to be conveyed. The worm, in revolving, screws the stock forward. A 6 in. worm running at 100 revolutions per minute, will convey 120 bushels of material per hour. The great value of the worm conveyor is due to the little room it occupies and the little attention it requires.

Band Conveyors.—The cheapest way, as far as power is concerned, to convey grain and other mill material is by band conveyors. It has, however, such a large capacity, and so many wearing parts, and occupies so much room, compared with a worm, that it is only used for transporting large quantities of stock.

It consists of two terminal pulleys, over which runs an endless belt, usually of canvas, covered with rubber. Between the terminal pulleys run two rails, along which are placed a number of rollers to support the belt. On the rails is placed a travelling throw-off carriage, having two pulleys round which the belt is deflected. This carriage can be fixed at any point along the rails, and when the load reaches it the deflection of the belt throws off the load, which is caught in a spout and thus sent to a bin, or machine hopper. When the load is always required to be delivered at the end of the conveyor, the throw-off appliance is not needed, as the load is discharged over the terminal pulley. The material to be carried can be spouted on to the belt at any point between the terminals. It simply lies on the top of the belt and is carried along, its own gravity causing it to remain on the belt. In some cases, instead of single rollers being used for the belt to run over, three or more short rollers, forming a rough arch, are employed; these trough the belt and so enable it to carry more material. The objection to this is the increased strain on the fabric of the belt, which has to flatten out again to pass over the terminals, or through the throw-off carriage.

Sack Hoists.—These appliances are used for hoisting sacks of wheat, etc., from one floor to another, or from boats and waggons to the upper floors of the mill or warehouse. They consist of a rope, or chain, of the necessary length, one end of which is attached to a drum or barrel. This drum is made to revolve by pressing two friction pulleys together. One pulley is attached to the barrel, and the other to a continuously revolving shaft. When the pulleys are brought together by means of a lever, the running pulley causes the other —and so the barrel—to revolve, and so wind up the chain or rope, the other end of which is attached to the sack of grain or meal. Some types of mechanical sack hoist are driven by means of a slack belt, which can be tightened to put the hoist into action by means of a lever. The introduction of elevators and conveyors for handling stock in bulk has greatly lessened the use of this appliance.

Sack Shoots.—A number of appliances have been introduced of late years for lowering full sacks from one floor to another without the consumption of power. They are all called sack shoots. The simplest form is a very smooth long plank set at an incline down which a sack of mill stuff will slide easily. The plank, of course, needs a strip of wood nailed down each edge to prevent the sack from rolling off. This type, however, requires a considerable amount of floor room. A more modern pattern is the spiral sack shoot, which is so simple as to need little explanation. Sacks can be dropped into it from any upper floor, and taken off at any lower one. Another shoot is practically a large wooden spout, with a door that can be opened at each floor. Inside the spout are a number of curved deflecting boards, which cause the sacks to slide down round them slowly.

Bleaching.—So keen is the demand for a pure white loaf, that the best flour is often bleached to remove yellow tints. This tint fades naturally if the flour is kept for two or three months, which gave imported flour a certain advantage in colour over the home-made article, which goes into consumption at once. Bleaching is a very simple process. A stream of air is electrified and pumped into an agitator, where it is thoroughly mixed with a stream of flour. Nothing but the electrified air is used. It is, indeed, the same sort of air that is forced into the London Tube Railways. Ozonized air, in fact; but more highly electrified for flour bleaching than for ventilating purposes. Bleaching low-grade flour would show up its defects, as it tends to emphasise the bran particles in it.

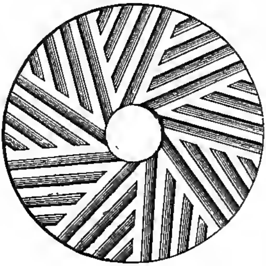
CHAPTER X

MILLSTONE MILLING

THOUGH the millstone has practically gone out of use for grinding wheat, yet it is still so largely used for other branches of milling that it is worthy of consideration in connection with the craft. It is generally used for making whole wheat-meal for brown bread. It is largely employed in Scotch oatmeal manufacture, and for grinding barley, maize, beans, pease, and other provender cereals into meal.

French Stones.—Wheat and maize are always ground on French burr stones. These burrs, which come in comparatively small pieces from France, are faced up, fitted and cemented together, and then hooped with two strong iron hoops to make up the complete stone. The face is dressed down to a perfect plane. The back, which has purposely been left rough, is covered with cement to any desired thickness, and rounded towards the centre. Each stone of a pair has a hole in the centre, called the eye. The eye of the runner is round, 10 in. diameter, while that of the stationary, or bed, stone is usually 10 in. square. Otherwise the two stones are identical.

The bedstone is laid on its back in a frame, called the hurst, and an iron plate carrying adjustable brass bearings is firmly fixed in the eye below the level of the face. A spindle runs up through the eye plate to a required height; its other end resting in a toe brass or foot step. The toe brass is fixed to a support below in such a way that it can be raised or lowered. On the top of the spindle is placed a driving iron, with two or three projectors which fit in sockets cut in the edge of the eye of the runner, or revolving, stone. When the stones are face to face, ready to start grinding, all the weight of the top stone rests on the driving irons, and so on the top of the spindle. The spindle is driven from below either by means of gear wheels or by pulleys and belt. The stones are enclosed in a circular wooden casing called the hoop, which has a hole in the centre corresponding to the eye of the stone. Over this is mounted a small hopper, the bottom of which is loose and called the shoe. A rod, called the damsel, coming up from the spindle and revolving with it, has cams which strike the shoe and vibrate it, causing a stream of grain to flow into the eye of the stones. Millstones are usually 4 ft. or 4 ft. 6 in. in diameter, and about a foot in thickness.



MILLSTONE

(Four furrows to the Harp, dressed to run with the Sun.)

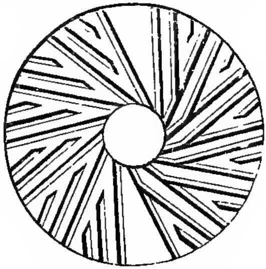
A 4 ft. 6 in. stone runs at a speed of about 130 revolutions a minute, and a 4 ft. stone at 140 to 150 revolutions.

The runner is accurately balanced on the top of the spindle to ensure even grinding. The wooden casing is far enough from the stone to give good clearance all round. A sweeper, attached to the periphery of the runner, carries the meal round with it, till it reaches an opening for its discharge in the case or frame.

Smooth stones would be of very little use for grinding, so various work has to be done on their faces to keep them rough, or, technically, sharp. This is spoken of as dressing the stones. The chief dress is the furrows ;

these are cut not radiating from the eye, but each of the master, or long furrows, is cut from a point 4 in. or 5 in. wide of the centre of the eye, and run thence through to the outer edge, or skirt, of the stone.

It is immaterial whether a stone runs with, or against, the sun, but, if against the sun, or left-handed, the master furrows lead from the other side of the eye. The face of the stone has two or three short furrows parallel to each master furrow, forming a "harp." Furrows are cut about a quarter of an inch deep at one edge, and taper away to nothing at the other. They may be $1\frac{1}{4}$ in. wide and have 2 in. of "land" between them; but there is no rule, most millers having opinions of their own on this point. A 4 ft. 6 in. stone has about ten master furrows, with three shorter furrows to each to form the harp.

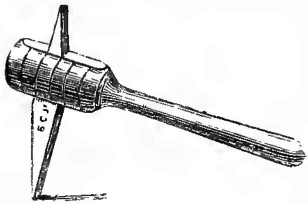


MILLSTONE

Showing two different dresses of three furrows to the harp. The second furrow on the left-hand view is cut through into master furrow. Dressed to run against the Sun.

The face of the stone is kept perfectly flat for about 8 in. from the extreme edges; from there it should taper slightly towards the eye to such a degree that, when the two stones, laid face to face, touch at the periphery, there should be nearly enough space between them at the eye to admit a grain of wheat. The outer 8 in. of the face has small lines, called "cracks," cut in the lands. These should be cut in clear and sharp, without breaking the face of the stone between them. To do this correctly on wheatstones was a sign of the highest skill in the old stone-dressers' art. These men boasted how many "cracks" to the inch they could put in. About twelve was the normal number, and a sharp mill bill, or pick, was necessary for the work. All the dressing is done with these tools, the workman sitting on the stone and resting his elbows on a cushion generally stuffed with bran. Only the best of steel will stand the work, and the tool has to be continually sharpened. The old stone-dresser has almost passed away, and it is hard to find a miller now who really understands a millstone, and can dress it.

The Derbyshire Peak millstone is of much rougher texture than the French, and is chiefly used for provender work. It is furrowed, and dressed, and worked in the same manner as the French stone, but is quarried all in one piece and cut into shape. It is customary to shrink a couple of iron hoops on the runner for the sake of safety, in case it should split at work, but this is not absolutely necessary, and many millers run them unhooped.



MILL BILL AND HANDLE

When a pair of millstones of any sort have to be dressed, the runner is turned over on its back, and the faces of both stones are dressed in exactly the same way, so that, when they are grinding, the furrows of the runner slightly cross those of the bedstone, and thus a shearing, as well as a grinding, action is obtained. It is partly for this reason that the master furrows do not radiate from the centre, but from points four or five inches wide of the centre. This distance is called the draught; and the greater the draught, the more quickly the material being ground travels from the eye to the periphery.

A pair of French stones require dressing once a week, a flour mill week being, generally, about 140 hours. To keep the stone faces true a staff is needed. This is built up of a number of strips of mahogany, glued and bolted together to prevent warping. It is about 4 ft. long by 5 in. by 3 in., and one 3 in. face is kept dead true by testing it on, and adjusting it to, an iron proof staff.

The true face of the wooden staff is lightly painted with a water paint. It is then rubbed over the face of the stone, or rather, on the skirt, or 8 in. wide circle of the face nearest the periphery, when any unevenness is at once marked by the paint, and must be dressed down as needed. If any part of the stone between the eye and the skirt is marked, it must be dressed off till the staff clears it.

Furrow strips are flat strips of wood, one the width of the furrows and the other the width of the "lands" between. These are used as rulers to mark the furrows, which are then dressed down to keep them to the correct width and depth. On French stones, the wear is infinitesimal, but the face soon wears too smooth to grind freely, and needs sharpening every week by "cracking" the skirt, and dressing the smooth face off the rest of the stone and the furrows, by lightly chipping with a sharp mill bill. It was considered a good day's work (10½ hours) for a stone-man to dress one wheat-stone.

In the latter days of stone milling mechanical stone-dressers were introduced, diamonds being used to cut or dress the stones, instead of the steel mill bill used by hand. They met with a certain amount of success, but the day of the millstone had nearly passed by then, and they were too delicate for the coarser dressing required for provender milling.

Within the last few years, composition millstones have largely superseded the old-fashioned, built-up French stones. These are made from ground French burr, mixed up with cement, in the same manner as concrete, and rammed into moulds to form the millstones. Sometimes emery is used instead of French burr. The advantages of the composition stone are: First, and most important, that the face, formed of small pieces, does not glaze, and so always keeps sharp; the only dressing necessary being a periodical deepening of the furrows. Second, a more even grit is obtained.

High speed mills, fitted with small diameter stones, are largely used for grinding various cereals, and especially for reducing the screenings, from the wheat cleaning department of flour mills, to fine meal for mixing into wheaten offals.

Besides the 23 or 24 million quarters of wheat imported into the United Kingdom every year, large quantities of other cereals are also brought over-seas. Maize, of course, is not grown here, at least for corn, though some is cultivated for fodder, so that the large quantity used is all sea-borne.

The table on page 121 will give a good idea of the quantities of breadstuffs, and of the coarser grains, imported into the United Kingdom each cereal year. The small arrivals of barley in the cereal year 1914–1915 was due to the closing of the Dardanelles, cutting off the usual large Russian supplies of that cereal.

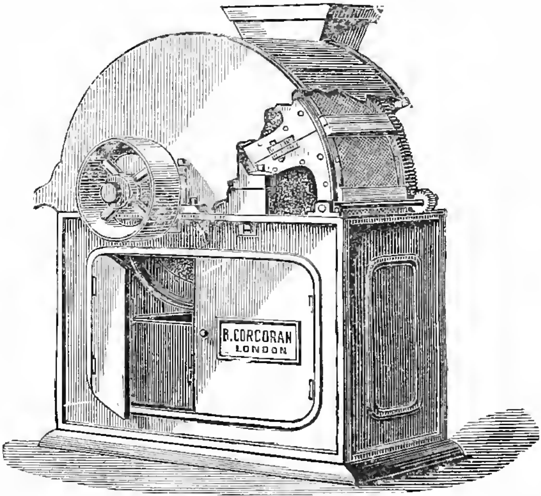
Maize.—Besides being ground on French burr, maize is often reduced on other types of machines. A great deal of this grain is used in distilleries, and is often ground on a three-pair-high roller-mill. The rolls are fluted, and the material having been broken down on the top pair, falls direct to the second for further reduction, and then to the third pair for finishing.

QUANTITIES OF BREADSTUFFS, ETC., IMPORTED.

	Quantities of Corn and Wheat Flour Imported in the Twelve Months from										
	Sept. 1, 1919, to Aug. 31, 1920	Sept. 1, 1918, to Aug. 31, 1919	Sept. 1, 1917, to Aug. 31, 1918	Sept. 1, 1916, to Aug. 31, 1917	Sept. 1, 1915, to Aug. 31, 1916	Sept. 1, 1914, to Aug. 31, 1915	Sept. 1, 1913, to Aug. 31, 1914	Sept. 1, 1912, to Aug. 31, 1913	Sept. 1, 1911, to Aug 31, 1912	Sept. 1, 1910, to Aug. 31, 1911	Sept. 1, 1909, to Aug. 31, 1910
	Qrs.	Qrs.	Qrs.	Qrs.	Qrs.	Qrs.	Qrs.	Qrs.	Qrs.	Qrs.	Qrs.
Wheat . . .	23,788,589	16,914,802	9,337,323	25,166,401	23,311,055	22,483,587	23,267,175	26,500,565	24,109,257	23,516,144	24,099,059
Wheat Meal and Flour . . .	3,642,760	5,669,699	9,205,421	3,732,560	3,245.958	3,529,573	3,654,048	3,648,883	3,324,139	3,263,385	3,501,523
Barley . . .	3,771,684	2,669,520	2,345,252	2,748,368	4,984,924	3,566,222	5,928,664	6,259,878	6,120,530	5,626,186	5,562,508
Oats . . .	2,859,985	2,657,279	3,700,487	3,911,061	4,777,733	5,519,374	5,520,534	7,183,597	6,611,636	5,974,024	7,038,110
Peas . . .	196,559	248,781	423,596	349,244	203,406	187,662	336,869	537,035	559,163	393,077	339,230
Beans . . .	479,357	388,763	92,494	263,636	276,298	385,181	368,778	266,396	252,032	179,395	468,058
Maize or Indian Corn . . .	6,566,676	2,690,398	3,656,870	8,571,924	8,714,512	11,203,276	9,375,868	11,557,461	7,493,370	10,721,996	8,083,217

[NOTE.—The equivalents used for converting wheat, barley, and oats from weight to measure are those set out in the Corn Returns Act, 1882, viz.: 60 lb. to the bushel of wheat, 50 lb. to the bushel of barley, and 39 lb. to the bushel of oats.]

Another type of machine is the high speed disc mill which grinds chiefly by percussion: the fluted, chilled iron discs revolving in opposite directions, and not actually coming in contact with each other, even when no grain is passing through. Another type is the disintegrator, which consists of beaters revolving inside



PEARLING MACHINE

a chamber at a very high speed, and reducing the grain entirely by percussion. Maize is never required to be ground into a fine, soft meal as are most other cereals.

Barley.—Barley was generally ground on Derbyshire Peak stones, because the coarseness and sharpness of the grit of these stones cut up the husk better than any other. Since their introduction, composition stones have been keen competitors of Peak stones.

Barley is required to be ground to a fine, soft meal, and the husk must be well ground to obtain this. It is not unusual for millers to sift the coarsest of the husks out of the meal and return them, continuously, to the stone with the barley being ground, so that they may be re-ground two or three times, till small enough to pass through the mesh of the sifter.

Pearl barley is produced by scouring the husk off the berry and leaving the endosperm unbroken. This is accomplished by means of a Peak stone revolving on a spindle in a cage made of stout, closely woven wire, the grain being scoured against the wire by the stone.

Oats.—Oats are ground for poultry feeding in much the same way as barley. For making Scotch or Irish oatmeal, the corn is first thoroughly dried on a kiln. It is then run through a pair of Peak stones ; the runner being raised from the bedstone to a sufficient height to only scour the oats and not grind them. By this means the hulls are rubbed off the oats, and are then removed by winnowing. The groats are then ground into meal of the required coarseness, either on millstones or on metal mills of various types. The chief difficulty was to scour the oats sufficiently to remove the hulls without damaging the grains that parted with their hulls first and most easily. Machines have now been introduced to separate hulled and unhulled oats, the latter being sent back for further scouring, while the former are passed on to be reduced to meal.

CHAPTER XI

CORN EXCHANGES

FROM time immemorial there have been Corn Exchanges, or recognised markets, for the buying and selling of grain. Probably the most important corn market in the world is "The Baltic Mercantile and Shipping Exchange," situated in St. Mary Axe, London, E.C.

The first "Baltic" had its origin, like Lloyd's, in a small tavern known as The Baltic Coffee House, or "Mongers," opposite the open pavement at the east end of the Royal Exchange. Here, merchants engaged in the importation of goods from Russia, and other Baltic ports, used to congregate over their coffee. Another tavern was the "Cock," and it is quite likely that different sections of the trade patronised various houses, until they were all collected under one roof, in the old Baltic, at the north-east corner of Threadneedle Street.

A building on the site of the old Baltic was famous, or, rather notorious, for being the home of the South Sea Company, originated by Harley, Earl of Oxford, in 1711. The South Sea Bubble burst in 1721. South Sea House, which was built in 1714, was partly destroyed by fire in 1826. It became the home of the "Baltic" in 1855, and was pulled down in 1900.

The market still retained its old coffee-house character in its new home, coffee, tea, and other refreshments, including luncheon, being served at the tables which lined the room. The Baltic Association, an unlimited company, bought the premises in 1855 for £40,000, and sold them in 1900 to the British Linen Company Bank for £350,000. In 1750, they had been sold for £5,000. The new Exchange is a combination of the old Baltic and the London Shipping Exchange, which latter, previously, was held in Billiter Street. The foundation stone of the new building in St. Mary Axe was laid by the Lord Mayor, on 24th June, 1901. The central hall, lit from a domed roof, is 150 ft. long. The ground is freehold and belongs to the new company, which is the largest mercantile association in the Kingdom, if not in the world, and all sprung from a coffee house of 150 years ago. Here, the London Corn Trade Association has its home, and here most of the international grain dealing takes place. Originally, the corn factors bought cargoes of grain on the Baltic and sold it to millers on the various corn exchanges of the Kingdom, and this is still largely done. Many of the milling firms, however, have of late years become such huge concerns that they now buy much of their grain from the shippers, and are themselves members of the Baltic, which, like the Stock Exchange, is a closed market, only open to members. There are numbers of grain brokers who buy wheat and other cereals for clients, on commission. The Atlantic is a similar Exchange in Liverpool.

Much of the grain is bought to be shipped from the ports of the country of origin by a certain date. Thus, soon after the American harvest, or even before harvest, cargoes, or parcels, are sold to be shipped by, say, the end of September, or by the end of February, or by any date between, though, as a rule, the terms are during a particular month; or the shipper may, in some cases, reserve the right to ship at any date during two months (*e.g.*, during December or January). Probably, a cargo may be sold "on passage" after the vessel has sailed. In these days of large vessels, one ship may carry a number of consignments for various shippers, and these are sold as parcels. All cargoes and parcels are sold on C.I.F. terms, that is, carriage and insurance free. The buyer has to take possession of the grain when the boat arrives, and pay all unloading and other charges. A considerable amount of grain is shipped "for orders." This does not mean that the grain has been ordered, but that the captain does not know to what European port he is going, and so has to call at a convenient port "for orders," as, during the voyage, the cargo may have been sold to a merchant, or miller, at any of a number of ports specified in the charter.

When grain was first imported, the foreign trade was in the hands of the German Steel Yard merchants, who originally came from the Hanse Town, and, about the year 1250, settled in Thames Street at the Steel Yard, or City Weighbridge, and so became known as the Steel Yard merchants. They obtained privileges from Henry III, which were renewed by Edward I, and also by the City authorities, in return for which they had to maintain the Bishop's Gate. Owing to the jealousy of English merchants, their privileges were revoked. They, nevertheless, still flourished till the time of Edward VI, when the Merchant Adventurers managed to obtain the revocation of their privileges. They remained here, however, till they were expelled in Elizabeth's reign.

So much for the foreign wheat markets, but probably the history of the markets for home-grown grain is even more interesting. London, in early days, drew the bulk of its breadstuffs and other cereals from the farms of the Home Counties, at a time when the corn trade was greatly harassed by laws and regulations, which, to a comparatively recent date, oppressed not only the trader but also the people. Henry VI prohibited the exportation of wheat when the price rose to 6s. 8d. per qr. In 1542, corn dealers were forbidden to hold more than 10 qrs. of corn at any one time, the idea evidently being to have no middleman, which would cheapen the price of the grain to the consumer—a fallacy not quite dead yet. Two years later, it was made a crime, subject to heavy penalties, for a person to buy corn to sell again. Up to 1789, England exported its surplus grain. The Corn Laws were abolished in 1846, with the exception of a registration tax of 1s. a qr. This also was abolished in 1869.

The first market we hear of was in 1438, when Sir Stephen Brown, the then Lord Mayor, established a public market and granary at Leadenhall. He also obtained cheap corn direct from Dantzig, and destroyed the monopoly of the Steel Yard merchants. Later, the Corporation and the City Companies provided the City with corn, and a large store was always kept at the Bridge House. The Great Fire, in 1666, destroyed all the Corporation's granaries, and they were never rebuilt, the provisioning of the City being kept in the hands of private traders. Foreign grain was landed at Billingsgate and Queenhithe. The City claimed the right of measuring this corn, which was done by sworn meters and fellowship porters. When the Corn Duties were repealed, the meters and porters were no longer necessary. In lieu of Metage, which was abolished in 1872, the merchants on the Old Corn Exchange had to pay 3-16d. per cwt. on all corn sold in the market. This duty was levied for thirty years on all grain imported into the Port of London for sale, and was called the City of London Grain Duty, and was applied for the preservation of open spaces, after a certain sum had been paid to the meters and porters as compensation for their loss of rights.

The principal corn market was in Cornhill, from which fact the street takes its name. Another was held at the west end of Cheapside. Bread Street takes its name from being the chief market for baked bread. Stratford was the great bakery centre, doubtless as being near the Essex wheat fields, and having good water carriage by way of the River Lea, which also provided power for a number of mills, of which Three Mills, now a distillery, was perhaps one of the largest, having a good water-power.

Bakers were subject to all kinds of restrictive laws, enforced by severe penalties. The Assize of Bread was first introduced by the City authorities, and afterwards regulated by Acts of Parliament, to compel the baker to increase the size of the loaf, or reduce it, according to the price of wheat. In the reign of Queen Anne a law was passed to remedy defects in the then existing regulations, but no one was satisfied, owing to the contradictory mode of fixing the Assize, as many cases of hardship occurred to the baker, and the consumer never knew what the price of his bread would be. In 1836, the Assize system was abolished, and, since then, bread, other than fancy bread, has had to be sold by weight. This, however, does not satisfy bakers, who are now trying to re-establish what they are pleased to call the Assize system, but which, to suit them, would have to differ from the old system, inasmuch as they claim the right to themselves to fix both price and weight, the latter to be, as far as their customers are concerned, an unknown quantity. They have already managed to carry out the scheme in parts of Lancashire, and neighbouring counties, which is rather expensive to their customers.

About two hundred years ago, numbers of Essex farmers used, once a week, to meet London millers at an inn in Whitechapel to sell their corn, and often, when they did not sell, they left their grain with the innkeeper to sell for them at a fixed price. Gradually, they got into the habit of sending their loads of grain to the innkeeper to sell, without going up themselves. Other men, seeing how much trade mine host was doing, induced farmers to send their corn to them to sell. These men took the grain to Mark Lane and Tower Hill to sell, where they met other factors who had received corn sent by water and landed at Bear Quay, in Thames Street. A market was, at one time, held at Bear Quay for the sale of grain landed there, but later was transferred by the Bear Quay merchants to a building situated at the back of 29 Mark Lane. When the number of factors had outgrown the accommodation there, a new market, the London Corn Exchange, was started in 1828.

The Whitechapel factors had previously combined, and, in 1746, obtained a short Act of Parliament, which granted privileges for a new corn market, which was built in 1747, and named the Corn Exchange of London. When first opened, the market was exposed to all weathers, business began at 7 o'clock in the morning, and candles had to be used in the winter mornings. It was closed in and partly rebuilt in 1827, when the restaurant known as "Jack's" Coffee House was added.

Under powers conferred by a new Act of Parliament, it was pulled down, and, on a greatly enlarged site, the present building was erected. When the London Corn Exchange was built, in 1828, at the north side of the other, it was generally called the New Market, to distinguish it from the Corn Exchange of London, which, naturally, became the Old Market. As mentioned, this latter was rebuilt in 1881, and strangers to Mark Lane are apt to be confused as the New Building is the Old Market, or Old Corn Exchange. Here, corn merchants have their stands, and sell the grain bought

C.I.F. on the Baltic to millers and other consumers, and here, also, are to be found numbers of country corn factors, who attend to sell home-grown grain that they have bought on the various country exchanges. A number of London millers have stands on this market, as well as the importers of American and other flours. The accommodation is even now severely taxed in busy hours, and it is next to impossible for a new firm to obtain a stand. The height is 70 ft., the area about 191,000 sq. ft., and the building cost about £106,000 to erect.

Most of the British corn exchanges have grown up in much the same manner as those in London. Some of the provincial exchanges belong to companies, while others are owned by the local authorities. The merchants pay an annual rent for their stands. Generally, farmers are charged a small fee to go on to sell their grain, but often the market is open to anyone, and, on some, farmers can sell their own grain without the payment of charges of any sort.

The import wheat trade of Great Britain is carried out on different terms with most of the exporting countries.

United States and Canada wheats, of various sorts, are graded according to quality by Government officials. Thus, we have Nos. 1, 2, 3, or 4, Hard Winter; or, it may be, Nos. 1, 2, 3, 4, and 5 Northern Manitoba. The grain is sold by the grade, on what are known as "Certificate Final" terms; which means that the buyer cannot dispute about the quality when the seller can produce the Government Inspection Certificate.

Indian wheats are bought here under various well-known names, such as, No. 1 Club Calcutta, No. 1 Bombay White, Red Karachi, Soft White Delhi, etc., etc. The actual wheats vary less, from year to year, than those of most other countries. The chief trouble has always been the dirt mixed with the grain, and shipments are always sold on a dirt basis, *i.e.*, if they contain more than an agreed percentage of dirt, the buyer can claim allowances in proportion.

Argentine wheat is sold at a guaranteed natural weight per bushel. When the wheat arrives this side, if a struck bushel of the grain does not weigh the guaranteed weight, the buyer is allowed 1¼ per cent. off the price of the wheat for each of the first 2 lb. per bushel and 2¼ per cent. for the third and fourth pounds that the wheat is below the natural weight guaranteed. If it is more than 4 lb. under weight, the matter is settled by arbitration. This weight per bushel has nothing to do with the actual weight bought, as the buyer receives 60 lb. for every bushel purchased, whether the wheat weighs 56 lb. or 62 lb. naturally. This bushel test is one of the best tests of the quality of wheat. A bushel of good, plump, dry wheat may weigh 64 lb. to 65 lb. per bushel, while poor, thin, damp samples may weigh 10 lb. less.

Australian wheat is bought here on what is called the F.A.Q. system. The Australian authorities make up samples to represent the Fair Average Quality of the crop. These samples are sent over here, and the shipments following are judged by them.

Russian wheats are sold by samples sent on ahead, and if the shipments contain a larger percentage of impurities than the samples, or above a recognised proportion of impurities, then the buyer can claim an allowance for dirt. Russian wheats are the most unsatisfactory sort that we receive in this respect, as the shipments are not officially controlled, and dirt is often mixed in wilfully by the native merchants.

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